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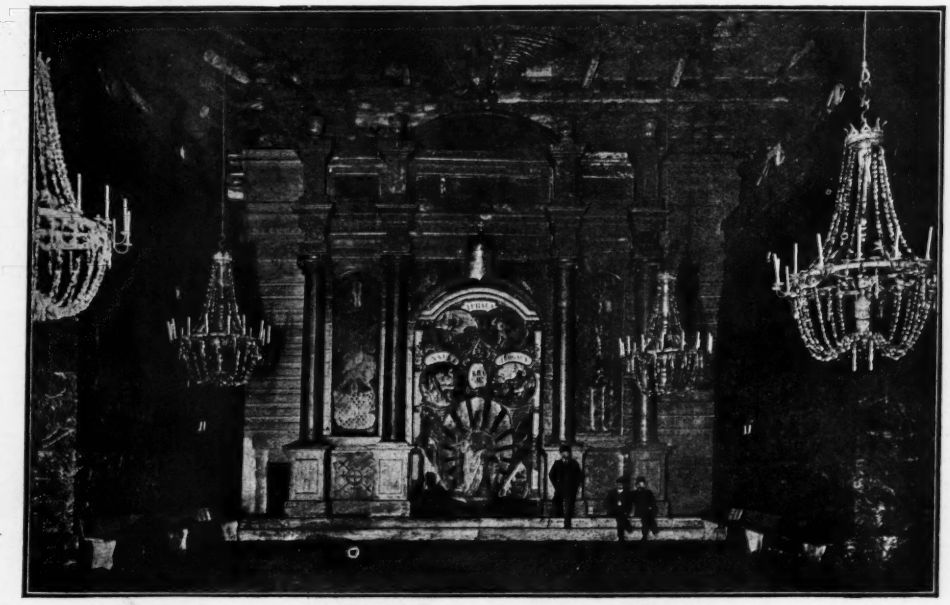
A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

EDITED BY EDWARD LIVEING, B.A.

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CONTENTS

	PAGE
EDITORIAL NOTES	309
A BUDDHIST TRAVELLER OF THE FIFTH CENTURY A.D. — Edward Liveing	311
EARTHQUAKES — J. J. Shaw	312
DID MAN EXIST IN THE TERTIARY AGE? — E. N. Fallaize	316
THE LATEST METHODS OF DETERMINING STAR DISTANCES — Dr. W. J. S. Lockyer	319
SALTS, BRINES, AND ALKALIS — R. C. Skyring Walters	322
PLANT BREEDING — I. B. N.	326
THE BERBER TRIBES OF MOROCCO — Dr. E. Gurney Salter	330
AMONG THE STARS—A MONTHLY COMMENTARY — Dr. Hector Macpherson	335
REVIEWS OF BOOKS	336
BOOKS RECEIVED.	339
CORRESPONDENCE	340

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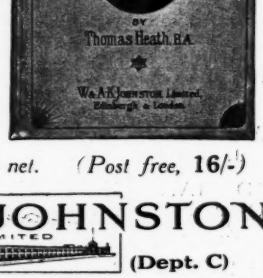
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DISCOVERY

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Editorial Notes

WE regret to have to inform our readers that this is the last number of DISCOVERY which will be published. No earlier announcement could be made, since efforts to preserve the life of our journal were continued almost up to the day on which this number was sent to press. The years after the late war have seen the initiation, the rise to popularity, and the fall in circulation of many magazines beside this one. Perhaps the chief cause of these failures lies in the depression in trade following so closely on the artificial prosperity that appeared after the Armistice. The result of this depression has been twofold: the cost of producing magazines has increased and the reading public has had less money to spend on them. We do not complain of our lot; from the outset we have striven to keep our readers in touch with the latest advances in knowledge both in the Sciences and in the Humanities.

* * * * *

In taking farewell of our readers, we think that a brief recapitulation of DISCOVERY'S short existence will not be out of place. The first conception of the journal was due to the late Professor Julius Macleod, of Ghent, a distinguished Belgian botanist, who was a guest of the University of Manchester during the war. His suggestion led to a special conference between a committee of the Council for Humanistic Studies and a committee of the Conjoint Board of Scientific Studies. As a result of this conference, negotiations were started and, through the enterprise of Mr. John Murray, our publisher, eventually ended in the appearance of the first number of DISCOVERY in January 1920. From the outset the magazine was under a deed of trust, the then Presidents of the Royal Society and of the British Academy being two of the four trustees, while a Committee of Management was formed, consisting of representatives of the National Union of Teachers, the Co-operative Union, the Library Association, the Incorporated Associations of Head Masters and Head Mistresses, the Head Masters' Conference, the Conjoint Board of Scientific Societies, the Classical, Historical, English, Geographical, and Modern Language Associations, the British Psychological Society, and the Royal Society of Economics. It was largely due to the help of these specialist societies that DISCOVERY was able to secure a supply of articles written by the men who were actually undertaking the investigations described, or were in other ways specially fitted for the work of reducing technical scientific phraseology to intelligible and interesting language.

* * * * *

We venture to say that no popular magazine published in England has ever before marshalled such an array of scientists and research workers in the Humanities in its army of writers. In the list of its contributors stand out such names as those of Sir Oliver Lodge; Sir William Bragg, one of the greatest pioneers in the wonderful modern researches into the structure of matter; Professor Sir Flinders Petrie, the greatest living authority on the life and history of the ancient Egyptians; Dr. C. S. Myers, a famous English psychologist; Sir Arthur Shipley; Professor A. C. Seward, whose work on fossilised plant-life has opened new vistas in the study of Botany; and Professor Conway, whose name is associated with the modern school of classical scholars that has revolutionised the study of the Greek and Latin civilisations and languages by showing the vast importance of their contributions to the civilisation of our own day. Among younger scientists who have described their researches and experiments in our pages have been

Professor A. V. Hill, who has this year been awarded the Nobel Prize for his work on oxygen and human energy; Mr. Julian Huxley, an Oxford biologist and grandson of the famous scientist, whose writings and experiments have attracted the keenest interest since the war; and Professor W. L. Bragg, who has co-operated with his father in recent epoch-making researches into crystal structure. It was in DISCOVERY that Professor Alfred Wegener first described for the British public his new theory of the origin of continents and oceans—a theory which has startled the world with its revolutionary conception of the nature of the surface of the globe. In the realms of archæology we have been fortunate in securing descriptions from the excavators themselves of three highly important post-war discoveries: Professor Peet has described his work on the site of the ancient city of the sun-cult at Tel-el-Amarna, in Upper Egypt; Professor Zaminit his discoveries of temples dating back to the later Stone Age in Malta; and Dr. Hall and Mr. Woolley their romantic "finds" in Southern Iraq of the temples and palaces of Ur of the Chaldees.

* * * * *

A leading article in the *Manchester Guardian* not long ago described DISCOVERY as "a sort of war correspondent of peace-time. It fetches to us laymen at home the exciting news from the various fronts where science is gaining hard-fought ground." Science has certainly gained much ground since the end of the war, and our knowledge of the universe and of life has been greatly increased, as also our knowledge of man in the distant past.

The teachings of Freud, Jung, and Adler have received widespread attention since the war, when psycho-analysis has been first seriously used in this country to cure nervous disorders. A vast literature, fictional as well as technical, has grown up in mush-room fashion on this remarkable science, which, despite its extremists and its conflicting schools, has already done much good in the treatment of abnormal characters and which is destined to teach us a great deal more about the normal human mind than we have ever known before.

Even more notable, perhaps, have been the strides made in physics and chemistry with Einstein's theory of Relativity and the work of Thomson, Rutherford, Chadwick, the Braggs, Soddy, Aston, Bohr, and other pioneers, which, by revealing to us the electrical composition of the atom, has put a completely new interpretation on the structure of matter throughout the universe.

Since the war physiologists have made rapid advances in the study of the ductless glands, or endocrine system, and the value of their secretions in building up and maintaining the human body; one of the practical results of this investigation has been the invention of insulin early this year, an extract of the pancreas gland of sheep used with considerable effect in the curing of diabetes. This year, too, bacteriologists have come very near to discovering efficacious inoculations against tuberculosis; time alone will show their value, but we can at least say that we are one stage "nearer home" in this direction. The problem of cancer is still far from being solved, but this year, again, has seen the initiation in England of a general campaign against the terrible disease.

Our knowledge of prehistoric times has greatly increased during the last four years. Indeed, it may be said that much of what was prehistory before the war is now becoming history. An article in this number demonstrates how archæologists and geologists have been tackling the question of whether man existed as far back even as the Tertiary Age. Many remarkable archæological "finds" have been made in Crete, Greece, Mesopotamia, and elsewhere, but, of course, the most sensational has been the discovery last year of Tutankhamon's burial-place, which has given us tangible, beautiful, and enormously valuable relics of the earliest known civilisation.

* * * * *

The application of new knowledge to industry and human endeavour generally has been attended with wonderful successes. The highest mountain in the world still remains unconquered, but we venture to think it will not hold out much longer. It is now no remarkable event in a business man's life to fly by aeroplane from London to Paris; speeds of over 250 miles an hour have been attained by aeroplanes, and a new class of light air machine with an engine of a few horse-power seems destined ere long to usurp not only the light car, but the motor-bicycle. This year has witnessed the consolidation of a wireless service within the reach of almost everyone, and the spectacle of families in the cottages of villages listening to concerts in London, Manchester, and even Paris. We are not likely ever to conquer earthquakes, but, as narrated in an article in this number, a scientist in England was wakened in the night, through the medium of an electric bell attached to his seismograph, by the recent earthquake in Japan.

* * * * *

The world in which our venture has played its part has been harassed by the aftermath of war and the perils of new wars. Only an optimistic person would predict that there is no danger of Europe being plunged into a war, that will overwhelm her civilisation, within the next fifty years. The alternative of peace is so entrancing, with its vistas of the application of

science to the task of harnessing the world's resources, and of an increasing spirit of international friendship in the general march forward of humanity, that we shall rest content if our journal has lit a small torch on the pathway of progress.

A Buddhist Traveller of the Fifth Century A.D.

AT a time when "self-interest" is advocated as a moral code to influence the actions of individuals and nations, it is encouraging to turn to the lives and teachings of the founders of the two greatest religions the world has yet been given, Buddhism and Christianity, and to those of the men who subsequently spread and fostered them.

It will be remembered how Gautama Buddha left his young wife and one-day-old child, and rode away into the Indian night, having renounced everything that was precious to him. That was 2,500 years ago, and many travels, pilgrimages, and wanderings have since been performed by his followers. None, perhaps, has been more remarkable than the travels of Fa-hsien, which even vie with the journeyings of St. Paul in the matter of dangers encountered, and certainly exceed them in the distances covered. This Chinese *shaman* set out from Ch'ang-an, in Central China, in A.D. 399, being "distressed by the imperfect state of the Buddhist *Disciplines*" and wishing to obtain these "Rules" in India. He walked practically the whole way across the Desert of Gobi, over the Hindu Kush and down through India to the mouth of the Hoogly River. Thence he took ship to Ceylon, where he remained for two years, finally returning by ship to China through the Sunda Strait. It took him fifteen years to accomplish his journey; he brought back with him the objects of his quest—books of the Buddhist Canon and images of Buddhist deities; and subsequently "he wrote down on bamboo tablets and silk an account of what he had been through, desiring that the gentle reader should share his information."

The first translation into a European language of this "Record" was the French version of Rémusat, published in 1836. Of later translations that of Professor H. A. Giles into English is most worthy of mention. It was first published in 1877, and this great Chinese scholar has now given the English public a revised version of his work.[1] "From this little book of travel," says the translator, "the unbiased reader may perhaps obtain a furtive glimpse of the grandeur of the Buddhist religion in the early years of the fifth century A.D." Fa-hsien's records show the vast institutional development, that had taken place in a thousand years, among Oriental peoples of the original simple and beautiful doctrines of primitive Buddhism. The monasteries, housing thousands of monks each, the richly built pagodas, the elaborate ritual of worship, the hundred and one places superstitiously associated with Gautama's saintly acts and endurances, legends and relics of all kinds, existing at that date from Tibet to Ceylon, are described by the *shaman* in vivid detail.

A typical passage is that relating to Ceylon, "not originally inhabited by human beings, but only by devils and dragons": "When Buddha came to this country, he wished to convert the wicked dragons; and by his divine power he placed one foot to the north of the royal city and the other on the top of Adam's Peak. . . . Over the footprint to the north of the city a great pagoda has been built, four hundred feet in height and decorated with gold and silver and with all kinds of precious substances combined. By the side of the pagoda a monastery has also been built, called No-Fear Mountain, where there are now five thousand priests. There is a Hall of Buddha of gold and silver carved work with all kinds of precious substances, in which stands his image in green jade, over twenty feet in height, the whole of which glitters with the seven preciosities, the countenance being grave and dignified beyond expression in words. On the palm of the right hand lies a priceless pearl."

Much research is now being made into the fundamental teaching of Gautama, which is being studied from the original sources. As in the case of Christianity, it has been overlaid with a complicated fabric of ritual and legend; "common men," as Mr. H. G. Wells [2] has said, "must have their cheap marvels and wonders." But at the same time it is universally acknowledged that the growth of both religions has inspired mankind with new and higher ideals and has been responsible for much of the world's finest literature and works of art.[3] Unselfishness and regard for truth are the central teachings of both religions. As a worker in the cause of Buddhism Fa-hsien lived up to its central doctrines. "That in the dangers which I encountered whether riding or on foot," he explained to one who met him at the end of his travels, "I did not spare my body, was because I kept my object steadily in view and concentrated upon it a simple honesty of purpose."

In the autumn months many a road in the East is still thronged with bands of Buddhist pilgrims going from one monastery to another. From a guide-book carried on such pilgrimages Dr. Carpenter, in his book referred to, cites a counsel of piety recorded originally by Mr. R. F. Johnston in his *Buddhist China*. It bears an interesting resemblance to the utterance of Fa-hsien: "It should be remembered that the proper object of the pilgrim's quest is truth; he must not expect to find his task an easy one. In this world of ours we cannot hope that heaven will make Buddhas of us for the asking. It is not till the plum-tree has endured the icy rigours of winter that its blossoming time will come. It is not till the pilgrim has won his way with zeal and courage through all the pains and woes of human life that he can hope to attain the objects of his quest."

EDWARD LIVEING.

[1] *The Travels of Fa-hsien* (A.D. 399–414), *or Record of the Buddhistic Kingdoms*. (Cambridge University Press, 5*s*.)

[2] Vide his *Outline of History*, chapter xxv: *The Rise and Spread of Buddhism*. (Cassell & Co., Ltd.)

[3] In Dr. J. Estlin Carpenter's recently published book on *Buddhism and Christianity* (Hodder & Stoughton, Ltd., 3*s*. 6*d*.) the reader will find the most luminous account of the teachings, development, and the contrasting and similar characteristics of the two religions yet written.

Earthquakes

By J. J. Shaw

Honorary Secretary, Seismological Committee of the British Association

THE investigation of earthquake phenomena, or Seismology, constitutes a most interesting study. It is really remarkable that, whilst other sciences have attracted so many workers, seismology has been almost entirely neglected. Perhaps this is because experimenters have not yet realised its fascinations, or maybe because earthquakes are not of everyday occurrence.

It is not necessary to live in an earthquake country in order to engage in their study; since it is possible to construct instruments, called seismographs, for the purpose of recording in diagram form—the seismogram—the various wave motions which are propagated uniformly throughout the Earth's mass.

By this means the exact time of their occurrence can be computed, also the precise area where they occur can be located, even if they are in the bed of an ocean; in fact, the greater number of shocks are located at the bottom of the sea.

An earthquake is by far the greatest demonstration of energy of which we have knowledge. It is capable of setting the whole Earth pulsating from pole to pole. The great earthquake in China in 1920 shook mountain ranges down until the valleys were filled up. The recent catastrophe in Japan furnishes us with an example of its destructive force. It is not uncommon for hundreds of thousands of lives to be lost in a few seconds.

Several attempts have been made to calculate the amount of energy liberated; in the case of a severe shock it is estimated to be of the order of 50,000,000,000,000 (fifty billion) kilowatts.

This energy radiates outwards in every direction: not only does it traverse the whole surface of the Earth, but it permeates also every cubic yard within. It is propagated in the form of waves of various types, each type having a characteristic speed.

Determining the Distance

In the same way that the distance of a gun may be determined from the flash and the sound, so also may an earthquake's distance, and the time at which it occurred, be computed.

There are three principal types of wave available for observation. The first to arrive at an observing station comes through the interior of the Earth in the form of a concussion, and is known as a compressional wave. The speed of this wave varies from 7 to 13 kilometres per second, depending upon the depth to which the chord, along which it travels, penetrates. This phase is denoted by P (primary). (See Fig. 1.)

The second type of wave travels via the same chordal route, but at a slower speed than the primary waves, viz. from 4 to 7 kilometres per second. These are transverse waves, so called because the vibrations, as in light waves, are at right angles to the path along which they are travelling. These waves are not only slower in speed, but the pulsations are also fewer per second, and have greater power. These characteristics give a wider and more open diagram, enabling them to be distinguished from the preceding primary waves. They are designated by the letter S (secondary).

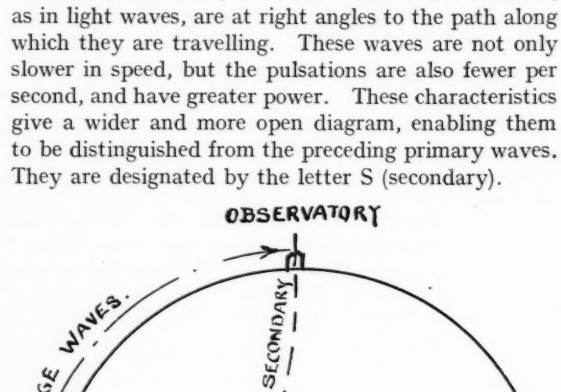


FIG. 1.—SHOWING THE PATHS OF THE PRIMARY, SECONDARY, AND LARGE WAVES.

Waves of the third type are similar to those waves which travel across a pool—they pass outwards from the epicentre, as the point on the surface above the origin is called, in ever-increasing circles, at $3\frac{1}{2}$ kilometres per second, along the Earth's crust. They are responsible for the largest part of the record and are known as the large waves, or maximum.

The evidence that these waves travel along the surface lies in the fact that, no matter how far they are propagated—and they sometimes pass more than once round the Earth—they travel at a constant speed relative to the distance measured on the surface; whereas the ratio of the length of a chord to the surface distance is constantly changing.

Since it is possible to recognise these different types of wave in the seismogram, it is obvious that these are the necessary data for estimating the distance they have travelled.

Let us take an illustration to make this point clear. If two trains leave London for the North, travelling at 60 and 30 miles per hour respectively, the express will reach a point 60 miles distant in 60 minutes, whereas the slow train will pass the same point in 2 hours, just 60 minutes later than the express. It is seen that the slow train is getting late at the rate of one minute for every mile run, hence at any point in its journey its lateness in minutes equals its distance in miles from London.

So with the earthquake ; the velocities of the various types of wave being known, as a result of many observations on previous shocks, the difference in the time of arrival of any pair is a measure of the distance of the origin, their common starting-place. For instance, when the secondary waves arrive 9 minutes 25 seconds later than the primary, the distance of the earthquake from the observatory is 5,000 miles ; and it can be further computed that the shock occurred 11 minutes 35 seconds earlier than the time of recording the first primary wave.

Before leaving this question of rates of propagation, it is interesting to remark that the first impulse arrives at the antipodes in about twenty-one minutes, after which, in the case of severe shocks, the whole Earth continues to pulsate for four to five hours ; and though it is far too feeble to be felt, every particle of matter and every living soul are rocked to and fro during this time. The titanic force of an earthquake is too stupendous for our full comprehension.

Locating the Position

The first primary wave which arrives at a station indicates the direction. It is either a " push " or a " pull " in a direct line with the centre of the shock. If this wave is accompanied with a rise of the ground, it is a " push " ; if the ground falls, it is a " pull."

Where a station is fitted with apparatus for recording all three components, namely, north–south, east–west, and the vertical motion, and a good record is obtained, it is possible to determine the direction from the data of one observatory.

A more satisfactory method is that where three or more observatories compare their readings. Each station calculates its distance from the epicentre. With three such distances as radii, and the respective stations for centres, circles are drawn upon the globe. At one point all three circles will meet. It will be at that point where the earthquake has occurred.

More precise determinations are made by the University Observatory at Oxford. This station, under the supervision of Professor H. H. Turner, F.R.S., is the international centre for collecting the reports from the various observatories throughout the world.

Earthquakes occur chiefly along well-defined belts on the Earth's surface. One belt nearly encircles the Pacific, the other stretches in a fairly straight line from the West Indies through the Atlantic Ocean, Southern Europe, and Asia, terminating in a fork running into Japan and the East Indies.

When the distance has been calculated for any station, a circle of that radius may be described around it. It is then possible to note at which points the circle cuts the main belts, thus narrowing down the possibilities where the earthquake may be. This method lacks very considerably in accuracy, but in the absence of other data it has the merit of being expeditious.

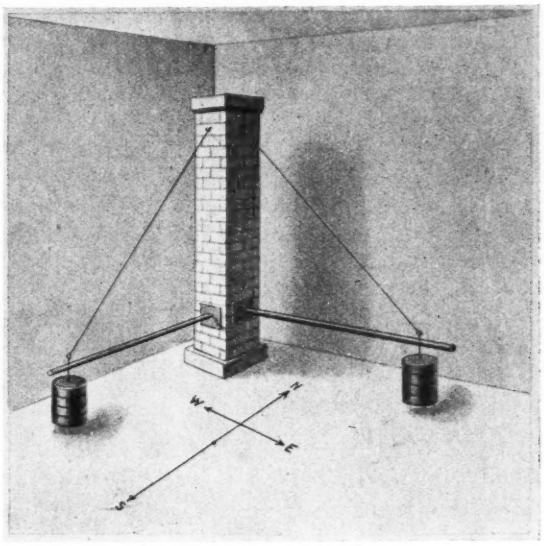


FIG. 2.

The Seismograph

Let us now consider the apparatus whereby the record, or seismogram, is made.

The basis of the seismograph in most cases is a pendulum whose movements, relative to the surface of the ground, are highly magnified before recording them.

The usual clock pendulum swings vertically, fairly quickly, and is not sufficiently sensitive for the work. It has been found that when a pendulum is mounted horizontally as shown in Fig. 2, where the top point of support is nearly vertically above, but a little forward of the lower point on the rod, it beats much more slowly, and becomes considerably more sensitive either to a horizontal thrust or tilting of the ground.

If the Earth movement approaches the pendulum end on, the pendulum is not affected ; therefore to

record movements from all points of the compass, it is necessary to mount two pendulums at right angles as shown in the figure.

In practice, one of the points of support is fitted with screw adjustments to regulate the degree of verticality. The more vertical these two points are set, the more horizontal becomes the plane in which the pendulum swings. This has the effect of lengthening the time for each swing, and the corresponding sensitivity increases as the square of this time of swing. Periods up to 30 seconds per swing are easily obtained, when the pendulum becomes from 200 to 300 times more sensitive than the usual seconds pendulum in a clock. But even so, when it becomes a question of being operated by the tiny wavelets that survive after radiating through solid material for

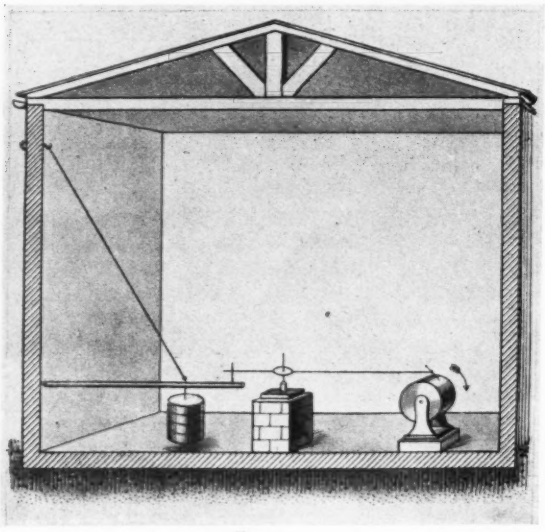


FIG. 3.

thousands of miles, the recorded movements are much too small to be of service, and this is where the designer or experimenter meets his great difficulty, namely, how to add a further great magnification when the restoring force of the pendulum has been reduced to its lowest ebb.

There are two alternatives: (*a*) increasing the weight of the pendulum; (*b*) reducing the friction of the magnifying devices to the utmost limit.

The former has been carried to one extreme, both by the Italian and German designers. Pendulums weighing as much as two tons are in use. In this case it is usual to use mechanical levers and pointers recording on smoked paper; and in some instances siphon recorders using ink on white paper.

Fig. 3 illustrates in diagrammatic form a seismograph recording on smoked paper.

The rod of the pendulum is 5 ft. long, carrying a weight of 300 lb. The lever magnifies the pendulum motion thirty times. The outer end carries a pivoted glass needle which is almost in equilibrium, but has a very feeble bias and so falls lightly upon the smoked surface of the recording drum. The recording pointer is raised from the smoked surface once per minute by means of an electromagnet not shown in the figure. This breaks the continuity of the line and so imposes the time upon the trace.

The drum is constantly revolved by a clockwork motor, and at the same time made to travel endways along the recording box. The trace drawn by the pointer forms a helix from one end of the drum to the other as a result of the two combined motions.

When a pendulum is disturbed, it requires a considerable time to come to rest. To obtain a true record of the ground movement, it is necessary to eliminate this natural tendency of the pendulum. For this purpose damping devices are used: such as vanes fitted to the pendulum and arranged to float in an air chamber or oil bath. A later and superior method is the utilisation of a copper vane floating in a strong magnetic field.

In the case of the heavy type of pendulum it is possible to fit an electric alarm. A bracket arm fitted to the outer end of the pendulum carries a platinum horseshoe, one leg of which rests in a globule of mercury; the other leg stands adjacent to a second globule whose distance is adjustable. These globules are the terminals in an electric-bell circuit.

The second globule is adjusted so as almost to touch the platinum contact. In this position the smallest oscillation of the pendulum rings the alarm. It was this device, the only one in this country, which roused the writer from bed a few minutes after the recent earthquake in Japan had occurred.

In the later and more delicate forms of seismograph the pendulums are sometimes as light as 1 lb.; the magnification is then achieved optically by moving beams of light recording on photographic film.

In another type the magnification is obtained electrically. The pendulum is fitted with a series of coils of copper wire which float in a magnetic field.

When the pendulum moves an electric current is induced in the coils and passes on to a recording mirror galvanometer.

Causes of Earthquakes

The cause of an earthquake has always been a subject for speculation. Neither Religion nor Politics have excited more controversy than this vexed question. The multiplicity of theories is a direct result of the paucity of real knowledge. It is generally

agreed that the focus of the shock is deep-seated, at a position in the Earth's interior where the conditions are unknown. It used to be fashionable to speak of the Earth's crust as about forty miles thick, and to believe that shocks occurred within that solid covering. Now, from observations of the variation in the time occupied by the primary waves in arriving at the antipodes, there is evidence to suggest that the seat of an earthquake may be as deep as 400 miles. The constituents of a star millions of miles away, by the aid of the spectrograph, are infinitely easier to investigate than the conditions a few miles beneath our feet.

As an instance of the diversity of opinion, two theories stand out in bold relief:

(*a*) The Earth is a cooling mass in which its outer shell has already become tolerably cool and solid. The interior continues to cool and contract, leaving the overcoat too large for the body. The overcoat wrinkles and creases like the skin of a drying apple. When the wrinkling reaches the elastic limit, the rocks snap, producing an earthquake.

(*b*) The Earth is a hot body whose outer shell is cooling and has become solid, and in its continued contraction becomes too small and too tight for the plastic interior, with the result that it occasionally cracks along lines of weakness.

Connection with Volcanoes

It is, perhaps, only natural that one flies to the volcano in the hope of fathoming the secrets of the interior, and it is a common impression that volcanoes are closely bound up in the earthquake phenomenon. This hypothesis appears to break down on closer examination.

When a volcano is in eruption, it almost invariably follows that earthquakes will be felt in the vicinity, but these shocks rarely provide sufficient energy to operate seismographs beyond a radius of a few hundred miles; suggesting that they are only minor adjustments after lava has been ejected, and are of a comparatively local character. On the other hand, the majority of the greater earthquakes emanate from regions where no volcanoes exist. This has been put forward as evidence that volcanoes are the safety-valves which prevent earthquakes. Not all the volcanoes in Japan, of which there are many, saved Tokio and Yokohama from destruction.

Another theory suggests tidal forces, where the Earth is supposed to be liquid within, and fitted with a thin, cold skin. The Sun and Moon as they pass set up a tide in the liquid interior similar to the tide in the sea, and so on occasions disrupt the crust and produce an earthquake. In this case it should follow that at the time of new moon there would be a preponderance of shocks. The examination of 15,000 earthquakes showed a preponderance amounting to 4 per cent. at this period; on continuing the examination and using 140,000 earthquakes, the law of average asserted itself and wiped out even this small excess.

The Latest Theory

The suggestion which has gained most favour, and seems to fit in with many observations, is the theory of Isostacy, which contends that all visible land is composed of the lighter parts of the Earth's crust and is floating upon the components of greater density.

Every mountain has its stream; every stream is gradually but continually conveying fine sand in suspension and soluble salts in solution to the sea. In the millions of years that have passed it is surprising that all land has not been washed into the sea, for there is ample room. If all the visible land were laid upon the bed of the oceans, there would be water to a depth of 1,200 ft. over all.

There certainly must be some process of restoration. The suggestion is that the Earth's outer shell is composed of great areas of material of different densities, and that the lighter areas float upon and in the heavier ones, in precisely the same way as icebergs float in the sea. If the difference in weight is small, the amount showing above the surface is also small compared with the amount immersed. In the case of the iceberg there is nine times as much below as above; and whenever the sun melts a layer from the top, the whole floats upward to re-establish the equipoise.

So with the mountain; as the tops are worn off they gradually rise above the plain, and of necessity require to break away round their lower edges where they meet the lower-lying ground in which they float.

It is this periodical act of severance which constitutes the earthquake.

The evidence to support this hypothesis is fairly comprehensive, and its chief points are—

1. The materials of which mountains are composed are generally lighter than that of the surrounding plains.
2. Evidence of sea-beaches on mountain-sides.
3. Marine deposits found at high altitudes.
4. That nearly all the great earthquakes occur either at the foot of mountain ranges, or at the bottom of steep declivities in the ocean bed.

But it is unwise to dogmatise on the cause of earthquakes; one can merely indicate the lines of modern thought. Probably there is a modicum of truth in them all.

Did Man Exist in the Tertiary Age?

By E. N. Fallaize

WHEN once it had been established to the satisfaction of the most prominent scientists of the day that the flints—afterwards known as palæoliths—discovered by Bourcher de Perthes in the Somme Valley in 1848 had been shaped by human agency, and were contemporary with the gravels in which they had been found, a vast field of speculation and research was opened up to the student of the history of man. These implements came from deposits assigned to the Pleistocene Age, which was the earliest stage of the Quaternary Epoch—the last of the divisions into which geologists had divided the earth's history as revealed by its rocks, and their associated characteristic fossils—and immediately preceded the "recent" times of present conditions. The exploration of Brixham Cave in 1858 confirmed the suspicions aroused by earlier discoveries in caves that man had lived contemporaneously in Britain with animals now extinct. These facts added thousands of years to the period during which, it was traditionally held, man had inhabited the earth.

Origin of Eoliths—Opposing Theories

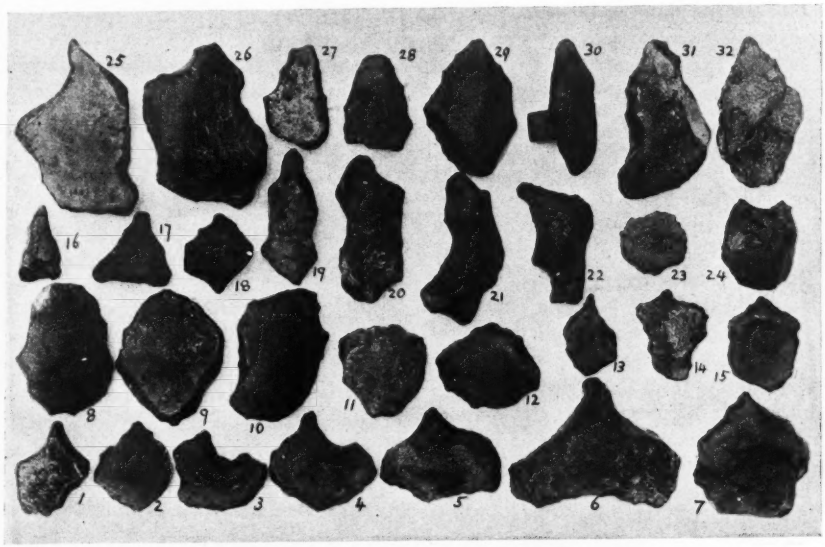
The publications of Darwin and of writers of the evolutionary school made familiar the idea that man and his culture were the products of a long course of development. By experiment archæologists learned the difficulties of manufacturing flint implements and came to appreciate the fact that the palæolith was by no means the rude stone implement of the popular writer, but was the result of long experience and the product of a highly developed technique. They turned, therefore, to the deposits of the Tertiary Epoch, the third of the great divisions of geological time, in the hope of discovering examples of an earlier and more primitive style in man's industry in stone which would serve as evidence of his existence in that era. Nor was it long before this was forthcoming. In 1867 L'Abbé Bourgeois announced at the International Congress of Anthropology and Prehistoric Archæology that he had discovered flints which bore evidence of human handiwork in the Tertiary gravels of Thenay. From that date students of the early phases of man's development have divided into two groups. On the one side stand those who accept the human origin of specimens for which Tertiary age is claimed, and continue from time to time to bring forward fresh evidence to support their case; while on the other side their opponents hotly contest the inferences which they draw. A vast literature has grown up around the subject in which the violence of the opposing sides is often more remarkable than the finality of their arguments.

It is not proposed here to examine in detail the arguments of either side, or to discuss *seriatim* the discoveries from various sites which have been held to be examples of the handiwork of Tertiary man. It is, however, necessary to review the question summarily in order to appreciate the bearing of certain recent investigations which appear to advance an appreciable stage towards a final solution.

To understand the nature of the problem of Tertiary man, it must be remembered that there are two questions involved: (1) What is the geological horizon from which any given specimen is derived, and, if the deposit is of Tertiary age, is it undisturbed, so that any specimen for which human origin is claimed may without any question be regarded as a contemporary with the associated gravels, fossil shells, remains of animals, etc.? (2) Are the chipping and shaping of the flint the result of purposive human action? This is a question of extreme difficulty, and in the majority of cases the one upon which opinion is divided with little prospect of agreement. Its consideration involves a highly technical knowledge of the mode in which a flint will fracture in different circumstances. It is well known that flint fractures under pressure and under the influence of heat or cold. The opponents of the eolith maintain that all specimens for which human purposive action is claimed are the result of the action of natural causes. Even the bulb of percussion which arises when a flint is broken by a violent blow, owing to the elasticity of its substance, can be produced by these forces, although it was once regarded as indubitable evidence of human handiwork. M. Marcellin Boule, some years ago, exhibited a number of specimens of typical eolithic character which had been produced by a stone-crushing machine in a cement factory. Mr. Hazzledine Warren, possibly the most determined opponent of the eolith in this country, has found in deposits in Essex specimens which he regards as typically eolithic in form, but necessarily the products of natural forces, as they belong to the first phase of the Tertiary Period, the Eocene, whereas the primates from whom man derives do not appear until the Oligocene, the second phase of the Tertiary.

The supporters of eoliths are not daunted by these arguments. They point to the fact that it is possible to classify the roughly fashioned flints into perfectly well-defined types—scrapers, borers, etc.—of which the uses may readily be conjectured, this obviously pointing to purposive action and not to a fortuitous result produced by natural causes. Secondly, they

deny that similar results could possibly be produced by natural causes. Mr. Reid Moir maintains that he has demonstrated this by a prolonged course of study of natural and artificial fracture and by experiment. Where two such experts as Mr. Hazzledine Warren and Mr. Reid Moir, both of whom have devoted close study to the subject over a long period, are completely opposed, the difficulty is not one of which a solution seems hopeful, at any rate on these lines.



A REPRESENTATIVE COLLECTION OF KENTISH EOLITHS.

I am greatly indebted to Mr. de Barri Crawshay and to his son, Mr. Raymond de Barri Crawshay, by whom the photograph was taken, for this illustration, which is particularly valuable and instructive, as it shows all the types of the Kentish eoliths. It has the further interest that some of the specimens, as shown in the table below, were found by Benjamin Harrison himself and are from his collection. Of the other specimens, most have been found by Mr. de Barri Crawshay himself or members of his family. The specimens are arranged in a series ranging from the crudest form up to the Plateau type of palæolith of acute form. The index numbers are the numbers of the specimens in Mr. de Barri Crawshay's collection. The scale may be gauged by specimen No. 32, of which the dimensions are 4¼ by 2¼ in.

No.	Locality.	Index Number.	Finder.	Designation.
1	West Yoke	2717	de B. C.	Right Hollow
2	,, ,,	2669	,,	Left ,,
3	,, ,,	2566	,,	Point and Hollow
4	Chirnhams	270	L.H. de B.C.	,, ,,
5	South Ash	1591	de B. C.	Reversed double Hollow
6	West Yoke	2564	,,	Double Hollow
7	,, ,,	25.2.90	,,	Pointed Pentagon
8	,, ,,	1012	Harrison	Ovate
9	,, ,,	1097	,,	,, pointed
10	,, ,,	25.2.90	de B. C.	,, pointed
11	Maplescombe	898	Harrison	Sub-triangular
12	West Yoke	2523	,,	Ovate
13	South Ash	2106	de B. C.	Point
14	Clads	10.1.21	,,	Pointed spalulate
15	Norstead	15.3.89	,,	,, ovate
16	Halstead	839	,,	Point
17	West Yoke	1010	de B. C.	Triangular
18	Speed Gate		L.H. de B.C.	Double-ended "Diamond"
19	Jerkins	25.4.91	de B. C.	,, ,, Fabricator
20	Old Terrys Pit	2373	Harrison	Treble Hollow
21	Surrey Plateau	2342	G. L. A. S.	Crook
22	,, ,,	2353	de B. C.	,,
23	Norstead	21.2.90	,,	Split pebble
24	Clads	5.1.20	,,	"Key" Hollow
25	Speed Gate	1683	,,	Crook point Hollow
26	West Yoke	2503	Harrison	"All round" Scraper
27	,, ,,	2578	de B. C.	,, ,, Point
28	,, ,,	2577	,,	,, ,, ,,
29	,, ,,	2665	,,	,, ,, ,,
30	,, ,,	25.2.90	,,	,, ,, ,,
31	Surrey Plateau	3269	F. L.	Acute pointed Flake
32	,, ,,	13	de B. C.	,, ,, Palæolith

Eoliths in Europe

The principal sites on which eoliths have been found are situated in France, Belgium, and Britain. Of these, those for which the earliest date is claimed are situated in France and Belgium. Of the four phases or periods of the Tertiary Epoch, the later three, Oligocene, Miocene, and Pliocene, only are in question. A claim has been entered for Eocene specimens, but it has hardly been received seriously. The finds at Thenay have already been mentioned. These, which belong to the Oligocene, were at one time supposed to show signs of the action of fire. They have been rejected by one authority who, however, accepts the evidence for finds of Miocene times at Le Puy Courny, near Aurillac, in the Department of Cantal. These flints were found in a deposit of alluvial sand which overlay a marine deposit and was itself under 10 metres of volcanic debris. Extensive finds on

the plateau of Hautes Fagnes, in the Ardennes, known as the Fagnian culture, have been the subject of careful study by M. Rutot, the eminent Belgian archæologist, whose carefully arranged and graded collection has carried conviction to more than one sceptic who previously was acquainted only with such selected implements as had been figured in M. Rutot's publications. Incidentally, in this connection it may be mentioned that those who support the eolith claim that no criterion is equal in value to the judgment which comes from the experience of handling and testing the adjustment to the hand of a large number of specimens, genuine and other. Up to the present the evidence for Miocene, and still more Oligocene, man has been regarded with considerable caution by archæologists. Recently, however, Professor W. J. Sollas, who has on more than one occasion expressed himself strongly against the human origin of many examples for which it was claimed, has examined a large collection of specimens from the Miocene deposits of Cantal, made by the late Mr. Westlake. His opinion, which was submitted to the Anthropological Section at the recent meeting of the British Association at Liverpool, is in favour of their being of Miocene date and possibly of human origin. He was, at any rate, prepared to go so far as to say that he knew of no natural forces in this area by which they could be produced. "They bear," he said, "cogent evidence of design." It may be hoped that these results will be published and made available for consideration at an early date.

Eoliths in Britain

In Great Britain eoliths have a farily wide distribution, principally in the South and East of England, the most important centres being Kent, on the chalk plateau in the area extending from Seven Oaks to the Darenth, and in East Anglia in the neighbourhood of Ipswich.

The Kentish finds occur in the red clay Tertiary drift which covers the chalk plateau, a few Pleistocene implements of recognised form occurring with the predominating ruder forms. These were first found by the late Mr. Benjamin Harrison, a life-long collector whose devotion to the study of the question of early man in Kent is worthy of the grateful remembrance of all archæologists. Specimens were submitted by Harrison to Sir Joseph Prestwich and accepted by him as of human origin in 1889, when he gave them the name of eolith. They were, however, rejected by such eminent authorities as the late Sir John Evans and Sir W. Boyd Dawkins.

Our evidence for Tertiary man in East Anglia is due largely to the indefatigable labours of Mr. J. Reid Moir, who for many years has devoted himself untiringly to the study of the prehistoric archæology of this area. Here, however, the problem is complicated by the introduction of a new type of implement of Tertiary age which Mr. Reid Moir and Sir E. Ray Lankester would distinguish sharply from the eolith. This is the rostro-carinate implement, a highly specialised type differing from the more generalised and rudimentary eolith in the peculiar shape indicated by its name, its sides converging to form a keel-shaped upper surface, while the sides and upper surface converge forward to form a beak. These specimens were found on the floor of London Clay under deposits of crag, 3 ft., middle glacial gravels, 15 ft., and later gravels, 7 ft. The human origin of these rostro-carinates has been strongly contested. Professor Sollas found a large number at Selsey Bill, but did not suggest that they were due to anything but natural causes, while Professor Boule, who examined the site personally, maintained that they did not differ from accidentally fractured fragments associated with them on the same surface.

The Foxhall Discoveries of 1920

Of the less highly specialised East Anglian types, which Mr. Reid Moir holds should be kept distinct from the Kentish eolith and for which he would prefer the name "pre-palæolith" or "pre-Chellean," the best-known specimens are those which were discovered at Foxhall, near Ipswich, in 1920. This find, which may be regarded as the culminating-point of a long series of investigations carried out by Mr. Reid Moir in East Anglia, is perhaps one of the most remarkable in the whole history of the eolithic question, not the least noteworthy of its results being the fact that it has served to convince such eminent and careful scientists as l'Abbé Breuil and Professor Fairfield Osborn, the American archæologist, that here we have indubitable evidence of man in the Tertiary Age.

Mr. Reid Moir's discovery aroused so much interest and gave rise to so much controversy that the question was taken up by the International Institute of Anthropology of Paris. An International Commission was appointed which included some of the most prominent archæologists and geologists of the day, among them M. Capitan, of Paris, M. Lohest, of Liège, M. Fourmarier, of Liège, Mr. G. Grant MacCurdy, of the American School of Archæology in Paris, Professor Nelson, of New York, and Mr. Miles Burkitt, of Cambridge. This Commission visited all the sites from which Mr. Reid Moir had obtained his specimens, and saw his collections. They also inspected collections at Cambridge, the British Museum, South Kensington,

and Mr. Westlake's collection of French implements at Fordingbridge, as well as Mr. Warren's collection of naturally fractured flints. The report of this Commission has now been presented to the International Institute and has recently been published. (*Revue Anthropologique*, 1923, pp. 53–67.)

The Report of the International Commission

The report consists of two parts, one dealing with the geological conditions of the find, the other, in part by M. Capitan, dealing with the archæological question.

The geological section, by MM. Lohest and Fourmarier, deals at greatest length with the deposits in an abandoned quarry at Thorington Hall. Here at the base of the excavation lies the London Clay (Eocene). Above this is the Red Crag (Pliocene), containing fossil shells (*Neptunea contraria, Pedunculus glycimeris, Natica*, etc.), some broken, others intact, with the two valves still joined. At the base of the Red Crag in a detritus bed including fragments of London Clay and unrolled flints, in which are found the specimens which it is claimed are the products of intentional fashioning by human agency. After a careful examination of this site, the authors of this section of the report, relying upon the appearance of the stratification and the occurrence of these fossils, which are of a type associated with Tertiary deposits, affirm that without any doubt it is undisturbed and of Pliocene age. Other sites were examined. Here, however, while deposits assigned to the Red Crag overlay Eocene sands and clays and the bed at the base produced humanly fashioned flints, in the absence of characteristic fossils such as were found at Thorington Hall, it was not considered possible to fix the age of the flints beyond question as contemporary with those deposits.

These conclusions are supported by a supplementary report by MM. Hamal-Nandrin and Fraipont.

In the report on the archæological problem M. Capitan gives the result of a rigorous test. Taking the collections of these implements, in number roughly a hundred, he rejected approximately one-half as being in any way possibly open to doubt. All rostrocarinates were included among the doubtful. From the remainder, about half were set aside as being probably of human origin ; but of the remainder, some twenty in all, he was of the opinion that there could be no doubt whatever that they were the work of man or of some subhuman percursor of man. And, indeed, several members of the Commission have pointed out that if this residue had been found among the rougher implements of a Mousterian find, no question would ever have been raised as to their human origin.

And here for the moment the matter rests. The general impression left by the report is that the question has been investigated in a thoroughly careful and scientific manner and that the report is scrupulously fair to both sides. On the archæological question M. Capitan's vast experience and his sound judgment must carry great weight. The geological evidence is beyond cavil, and until it has been possible for someone to show that on the archæological question the judgment of M. Capitan and his colleagues is at fault, this report would appear to justify the conclusion that one site at least has produced indubitable evidence of Tertiary man in East Anglia.

The Latest Methods of Determining Star Distances

By William J. S. Lockyer, M.A., Ph.D., F.R.A.S.

Director of the Norman Lockyer Observatory, Salcombe Hill, Sidmouth

A KNOWLEDGE of the distances of the stars is one of the most essential requirements of modern astronomy, and its importance in the problem of exploring and understanding the universe is fundamental.

Otherwise it would be difficult, if not impossible, to obtain any information concerning the actual brightness of the stars or their sizes, masses, densities, and other characteristics—all essential parts of any intelligent account of the universe and without which our knowledge would be wholly parochial.

Early Methods

Acting on the assumption that the brighter a star is, therefore the nearer it must be to us, the early astronomers made an attempt to arrive at an approximate acquaintance with the distances and consequent distribution of the stars in the universe. Even then no idea of their actual distances was secured, but simply their relative distances.

Observations of the stars, night after night and year by year, by means of the Transit instrument or Transit Circle led astronomers to determine the position of stars with very great accuracy. It was soon noticed that some stars changed their places owing to

the fact that they were moving comparatively quickly; it was therefore concluded that their motion was apparent because these particular stars were nearer to us, just as the motion of a man walking at a distance of a hundred yards is more easily observed than one walking at a distance of a mile. It was found that it was not necessarily the bright stars which exhibited the greatest motion, so that the assumptiom made by the earlier astronomers was proved to be untenable.

The first successful attempt to determine the distance or "parallax" of a star was accomplished by Bessel in the year 1837. He showed that the star 61 Cygni, a star of about the fifth magnitude, had a parallax of about one-third of a second of arc. This is a very small quantity to measure, but it is really large as regards the parallax of a star. The method he adopted was exactly similar in principle to the processes of surveying land at the present day. As stars are immense distances away from us, a short base-line is of no avail, so he employed the largest one possible. This consisted of a length equal to a line joining the positions of the Earth at opposite points of its orbit, that is a base line of 186 millions of miles. The process of observation consisted in determining at a certain time the exact position of the star in question and then making similar measurements six months later. The apparent change of position due to the translation of the observer gave a value of its distance. This method is known as the "absolute method" and may be considered one of the most difficult operations in the whole field of practical astronomy.

The method of "parallactic motion," which is the apparent movement of the stars due to the velocity of the solar system as a whole in space, is another means of obtaining trustworthy values of the average distance of a group of stars, though not of individual members.

At a later date another process for determining stellar distances was evolved, called the "differential method." For this the position of the star to be studied was measured in relation to neighbouring stars at different times of the year.

The application of photography to astronomical problems has greatly facilitated this method, because by photographing the star region at the specified times, the position of the star in question in relation to the other stars on the plate can be measured at leisure.

In spite of the great length of the base-line, the values of the parallaxes are so small that they are extremely difficult to measure. Very great care has not only to be exercised in the observations themselves, but every possible source of personal and instrumental error has to be taken into account and eliminated as far as possible. As the observations have to be spread over at least six months, the determination of every single parallax is a lengthy process.

The New Spectroscopic Method

In the year 1914 the spectroscope was first applied to the determination of stellar distances, and this new method, now coming into more general use, was originated and developed by Professor W. S. Adams and other astronomers at the Mount Wilson Observatory, in California. By its means parallaxes can be obtained with comparative ease and rapidity.

The spectrum of a star is obtained by passing the light of a star through a prism or train of prisms attached to a telescope. A star's light is thus spread out into a long band of light having the colours of a rainbow, extending from violet at one end through indigo, blue, green, yellow, orange to red at the other end. This band is the analysis of the light of the star and is termed its "spectrum."

Throughout this spectrum lines or bands can be observed in different parts of it, and these by their positions indicate the presence in the star of particular substances such as gases, metals, etc.

The spectra of many thousands of stars have been photographed, and, astonishing to relate, these spectra can be classified into so few as approximately fifteen different types. The type of spectrum is indicative of the temperature of the star. It is now known that stars which give gaseous lines in their spectra are hot, those that exhibit metallic lines are cooler, and those which indicate bands are cooler still.

Now the life of a star consists first in increasing its temperature or getting hotter; then a maximum temperature is attained, after which it cools and the star eventually becomes invisible. It will be seen, therefore, that if two stars have the same temperature, it is quite possible that one star may be getting hotter while the other is becoming cooler. This is a very common occurrence.

The peculiarity about stars at the beginning of their careers is that they are of great size or volume and have very small density: the older they get the smaller becomes their volume and the greater their density. Thus *young* stars are very much bigger than *old* stars, and this had led astronomers to call the former "giants" and the latter "dwarfs."

Now it is quite easy to understand that if a "giant" star and a "dwarf" star of the same temperature were placed at equal distances from us, the former would outshine the latter on account of his greater size, or in other words the "giant" would have a greater "intrinsic" brightness.

If all the stars had the same individual intrinsic brightness, then the nearer stars would be the brightest

and the most distant the faintest, and the original assumption of the earlier astronomers mentioned before would have been correct. But stars differ very considerably in intrinsic brightness. If, therefore, all the stars were placed at the same distance from the Earth, they would appear of different magnitudes, or would have, as it is called, different "absolute magnitudes." The unit of distance adopted by astronomers is that distance where the parallax would be 0″·1, and the absolute magnitude of any star is its apparent magnitude when reduced to this unit distance.

Now if the distance of a star is known, as it may be by one of the methods previously described, and if, also, its apparent magnitude is known, as is the case with most stars, then it is quite easy to determine the star's absolute magnitude.

How it is Employed

The principle on which the new method is founded is that the intrinsic brightness of a star has an appreciable effect on its spectrum. Thus, if two stars have the same type of spectrum or have approximately the same temperature, but differ greatly in luminosity, they will probably differ greatly in size, density, and in depth of their surrounding gaseous atmospheres. If this be so, then their spectra should exhibit variations in the intensity and character of such lines as are peculiarly sensitive to the physical conditions of the gases in which they find their origin, in spite of the general correspondence between the two spectra.

It has been found by Hertzsprung and Adams and Kohlschütter that certain lines in stellar spectra do give indications of variation with absolute magnitude.

An examination of these spectra shows that certain lines are more intense if a star is of great absolute magnitude than if it is of small absolute magnitude. By measuring the intensities of these lines with respect to other lines in the spectrum, it is possible to determine the true absolute magnitudes of the stars. Having obtained thus the absolute magnitude, and knowing the apparent magnitude, then the parallax can be easily determined.

The first step in the process is to have available a classification of star spectra like that previously mentioned based on detailed measurements of line intensities. Such a classification already exists and is rapidly being extended. It is next necessary to construct a series of reduction curves for each type or class of spectrum, or for small groups of types. These curves are based on the calculation of absolute magnitudes of stars from known data such as the apparent magnitudes, and the trigonometrical parallaxes and the relative intensities of selected pairs of lines carefully measured.

Having now formed these curves it is then a simple matter to measure the intensities of special lines in any star spectrum and determine the star distance.

Naturally greater accuracy is obtained when more than one photograph is examined and several pairs of lines in them are used, but this involves very little extra labour.

The rapidity with which the determinations of parallax can be secured, when once the fundamental curves are formed, is far in excess of that of the older methods.

The large powerful telescopes of the present day are capable of photographing the spectra of very faint stars, so that a rapid survey of the whole heavens, at any rate to stars of about the seventh magnitude, will be accomplished in the near future.

Any observatory that possesses a large number of stellar spectra can utilise them for this purpose.

A little more than a year ago the spectroscopic determinations of stellar parallaxes were confined entirely to the United States, at the Observatories of Mount Wilson and Harvard College. The Astrophysical Observatory at Victoria, B.C., has recently proposed to work up their spectra in this research.

In this country the only observatory that has been and still is occupied with this work is the Norman Lockyer Observatory at Sidmouth, but the Director of the Stonyhurst College Observatory has recently announced his intention of taking up this subject.

At the Sidmouth Observatory the parallaxes of 500 stars have already been determined and published by the Royal Astronomical Society, and another similar number will soon be completed.

An interesting point in connection with this observatory's work is that the measurements of the intensity differences between pairs of lines are being made by a method, originated by the writer, which is different from either of those used at the American observatories. Thus a comparison between the American and Sidmouth values is of special interest.

This opportunity may be taken to point out the valuable assistance which was given by the Department of Scientific and Industrial Research which rendered possible the undertaking of this research on so large a scale.

SCIENCE, PHILOSOPHY, AND RELIGION

In an age such as ours when men are striving to extract some meaning out of the confusing experiences and impressions of life, the need for books explaining in a popular yet authoritative way the relative values of science, philosophy, and religion, and the manner in which these three separate branches of human knowledge and mental and emotional activities can be brought to bear on the past, present, and future problems affecting mankind, is very great. We think that this need is well supplied by a new *Library of Philosophy and Religion*, edited by Dr. W. Tudor Jones, the first three volumes of which have recently appeared—*Metaphysics of Life and Death*, by Dr. W. Tudor Jones; *Buddhism and Christianity*, by Dr. J. Estlin Carpenter; and *Aspects of the Study of Society*, by Mr. R. T. Evans. (Hodder & Stoughton, Ltd., 3*s.* 6*d.*)

Modern Industries—VI

Salts, Brines, and Alkalis

By R. C. Skyring Walters, B.Sc., Assoc.M.Inst.C.E.

Salts—their Distribution and Composition

THE salts that are distributed over the globe give rise to many industries, some great, some small, and several large volumes would be required to describe adequately the geological, metallurgical, chemical, mechanical, and economic considerations upon which such industries are based. Here, however, a few typical industries are outlined to show as simply as possible, firstly, the complexity of the problems connected with the formation of the raw materials, and, secondly, the complexity of the problems involved in their conversion into finished products for the use and convenience of man.

Without going into statistics, we all know sodium chloride, or ordinary common salt, is one of the most widely distributed of the salts in nature, in which state it is called rock-salt. It is also probably the salt most used by man, not only directly for flavouring and preserving food, but indirectly for the manufacture of alkalis, washing-soda, and soap. Salt, Geikie states, occurs in rocks of all ages, in the pre-Silurian rocks of the Punjab, in the Silurian of America, in the Carboniferous of Australia, in the Permian and Trias of Germany and England, in the Tertiary of Poland and France, and is being formed at the present day in the salt-lakes of Utah, the Dead Sea, and in the desert of Kirgis Steppe in Siberia.

In England, salt is usually associated with the Red Keuper Marl of the Trias series. These rocks mould the scenery of a large portion of central England. The hard red sandstone beds generally form conspicuous hills, and the marl and clay beds, the low-lying ground around them, and the floors of valleys in between. In Cheshire the Keuper Marls, which contain the salt-beds, are some 3,000 ft. thick, and were all originally deposited in water; the sands and clays being the settlement of the muds of the ancient seas washing against ancient land cliffs, or of muds brought down by rivers draining the ancient land-surfaces; the rock-salt (and other things) being the chemical precipitation of certain substances originally in solution, which have separated out owing to certain physical conditions prevailing at the time.

In these seas and sediments several materials existed, in solution or as solids; a few of the salts may be noted thus: Salt (Sodium Chloride), Carnallite (Potassium and Magnesium Chloride), Calcium Chloride, Sodium Sulphate (Glauber's Salt), Kainite (Potassium and Magnesium Sulphate with Potassium Chloride), Gypsum (Calcium Sulphate), Celestine (Strontium Sulphate), Natron or Washing-soda (Sodium Carbonate), Potassium Carbonate, Magnesite (Magnesium Carbonate), Chalk or Limestone (Calcium Carbonate).

It would take too long, however, to explain, even if it were possible, how these several substances, at one time more or less in solution, came to be crystallised out so as to form the solid deposits on the earth's crust as we now see them. The conditions for crystallisation of more than one substance in the same solution is very complicated. If one substance only is in solution the case is simple, as the water can only contain so much of that one substance, and if excess of that substance is added, it remains undissolved. But if two substances are dissolved in the same water—for instance, salt and gypsum—and the water is evaporated, some of the gypsum will crystallise before the salt. Thus seams of gypsum are sometimes found below seams of salt. If five or six different substances are in a solution, it is found not only that some crystallise out before others, but that some combine, forming double salts which have each its own rate of crystallisation. Again, some salts dissolve others; thus while pure water dissolves 254 parts per 100,000 of gypsum (Calcium Sulphate), strong brine dissolves 719 parts per 100,000, and, to complicate matters still further, certain of them cannot exist together in solution at certain *temperatures*.

How is Rock-salt Formed?

An idea of the possible origin of rock-salt, however, may be easily gleaned in the following way: Let the reader imagine a lake or sea with one inlet and one outlet for water. Now as salt is distributed in nature in small quantities and is soluble in water, water which flows into the lake carries salt with it; thus, water that has flowed over vegetation will bring in about 2 parts per 100,000, spring-water about 4, and even rain-water about ·36. These waters, with a minute quantity of salt dissolved in them, flow into the lake, and carry with them silt and mud which, in depositing, forms a bed of clay or marl. When this process has taken place the inflowing water stops and the *water* in the lake is evaporated, possibly by a tropical sun, and as the salt dissolved in the water does not evaporate, the proportion of salt in the water continually increases as the latter is being evaporated. This is comparable to what goes on in a steam-boiler. The solution becomes more salty than the sea (that is, more than 2 to 3 per cent. of salt) until strong brine containing 26 per cent. of salt is formed. Now let us see what happens when the evaporating process is continued upon the brine-solution. The brine is not able to dissolve any more salt; if any salt were put

into this brine it would not be dissolved; conversely, if more water is evaporated and taken away from the brine, salt will crystallise out and will be deposited as a bed of rock-salt. And last of all this bed comes to be preserved for all time by a bed of clay, through which fresh water cannot penetrate to redissolve the salt; this bed of clay is formed from sediment from the fresh-coming water. This fresh water probably very largely travels over, without disturbing, the heavier brine. (A gallon, or ·16 cub. ft., of water weighs 10 lb., whereas a gallon, or ·16 cub. ft., of brine weighs 12 lb.) We may therefore imagine this process being repeated through untold ages, for the deposits are upwards of 4,000 ft. thick: wet seasons being represented by marls, clay, or sandstone seams; and dry seasons, by rock-salt seams.

In England rock-salt appears in beds of 1 in. to 100 ft., of various colours; the red being due to oxide of iron; the green, to chloride of copper; the blue, to silicate of copper. It contains several other impurities —clay, sand, bitumen, gypsum, Calcium and Magnesium Chloride (the latter being responsible for its deliquescence, i.e. its capacity for absorbing moisture). There are cavities that are filled with brine and various gases. Fossils are sometimes embedded in it. Gypsum is often found in layers of various thicknesses; thus at Stassfurt there is a bed of pure rock-salt 685 ft. thick, with thin layers of Anhydrite (gypsum without water), a quarter of an inch thick, at intervals of 1 to 8 in. throughout the bed. At this place also other salts—Carnallite, Kieserite, Polyhalite—occur in thick beds. In France there is a rich deposit of Potassium Chloride associated with rock-salt, which is known as sylvinite. Most of these salts have been preserved by clay-seams in the manner indicated, but other salts, such as those that are only very slightly dissolved by water, are found at the surface, an example being Celestine, which occurs in patches in the Trias in Gloucestershire.

How is Rock-salt Obtained?

Rock-salt-winning is a very ancient industry. In olden times it was obtained from the sea, by leading the sea into shallow lagoons and evaporating the water by the heat of the sun, thus imitating on a small scale the natural process of the formation of a rock-salt bed. This method is pursued in several parts of the world at the present day, notably in China. The actual mining of rock-salt is carried out on a large scale in several parts of Europe, for example at Wieliczka, near Cracow, in Poland. Here the underground galleries have a length of some 65 miles; some of these are converted into show-places for visitors and lighted by electricity, provided also with houses, churches, ball-rooms, restaurants, lakes, bridges, and even railway stations. Fig. 1 gives a view of the Francis Joseph Ballroom, everything, including the chandeliers, being composed of salt. It may be noted *en passant* that

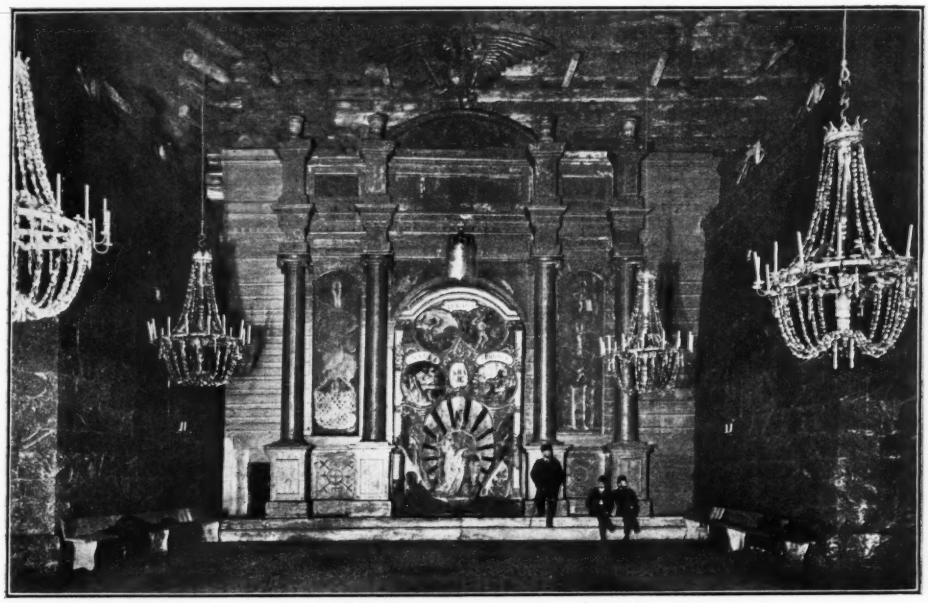


FIG. 1.—WIELICZKA SALT MINES, GALICIA.
The beautiful Francis Joseph Ballroom, made of salt. The chandeliers are made of polished salt crystals.
(By courtesy of Sir Isaac Pitman & Sons, Ltd.)

salt is twice as strong as bricks in compression. It will be readily understood that no water whatever has any access into the workings, which attain the considerable depth of 12,000 ft. below the surface. In the past disasters have occurred owing to the influx of underground waters into the mines.

In England, down to 1850 most of the rock-salt deposits in Cheshire and Worcestershire were mined; as such mines one by one became flooded, brine-pumping was resorted to, and at the present time, salt in England is almost entirely obtained from brine. The overlying clays are so punctured that fresh surface-water has now had access to the beds of rock-salt, in which are sunk several bore-holes. The brine is usually lifted by an air-lift which forces compressed air to the bottom of the bore-hole; then the force of the compressed air rising to the surface lifts the brine. Fresh water probably finds its way through salt deposits in underground channels which are continually being enlarged owing to the dissolution of the salt by the fresh water travelling through them; occasionally the brine appears to be over-pumped, i.e. its level in the bore-hole sinks considerably; this is attributed to the underground channel in the rock-salt being temporarily blocked by a collapse of the clay-roof above the rock-salt. But when the brine-level in the bore-hole is lowered, a greater hydrostatic pressure is put on the brine, which thereby usually cuts another way through to the shaft and so returns to its normal level. Naturally, considerable damage occurs at the surface in subsidences with all this disintegration and dissolution going on underground, at a depth of not very much more (in many places) than 150 ft., and damage to property in the district occurs from time to time.

Manufacture of Salt

There are several processes of extracting the salt from the brine; one very recently adopted is known as the Hodgkinson process. In this the brine is pumped into a large enclosed pan, 30 ft. in diameter, which is heated by the hot gases from a mechanically stoked furnace. The temperature of the hot gases is so controlled that the crystals of salt can be varied in size; either very small crystals can be made for table-salt or large lumps for salting and packing fish. There are two other smaller secondary pans in which table-salt is produced, and the gases pass on to four large rectangular open pans 60 ft. by 25 ft. where coarse crystals only are made, a slower rate of evaporation and crystallisation taking place in these pans. By this process about 7 tons of salt are produced to every ton of coal consumed, and the finest table salt is produced without grinding the larger crystals. In the older process (of evaporating brine in open pans with the furnace in contact with the pans), only 2 tons of salt were produced per ton of coal, and finer varieties of salt had to be obtained by grinding the coarser crystals. The extraction of the salt by this process and the use of the air-lift in pumping the brine, instead of the expensive method of quarrying rock-salt, has revolutionised the industry.

Rock-salt and Public Water-supplies

It must be said, however, that the quarrying of rock-salt, providing that the workings could have been kept dry at all times, had the great advantage of being under control, the roofs being propped up and not allowed to fall in. With brine-pumping, subsidences occur, but nobody knows where or when they are going to take place. The whole of the top-water in the strata of the district is becoming, to say the least, brackish. Wells have to be abandoned and both public and private water-supplies are becoming affected. In the immediate future big problems may have to be solved by local authorities, to cope with the question of water-supply, since several large towns have wells in proximity to this salt region. Moreover, brine may travel many miles through the adjacent porous sandstones of the Keuper, Bunter, and strata of more or less porous deposits of glacial-drift-gravel which now fill up pre-glacial valleys. Such brine or brackish waters may appear again in most unexpected places. It may be noted that Sodium Chloride, which is so very easily dissolved by water, is exceedingly difficult to extract from water, and it is only by evaporation that it can be so extracted. This would be quite impracticable in any water-works; even on board ship it takes 1 lb. of coal to render a gallon of sea-water fit for drinking by repeated evaporation and condensing, and even then it is not very palatable.

Alkali

In some places, therefore, bore-holes have been sunk some distance away from the rock-salt beds, by the makers of alkali. In other places brine is conducted in pipes, as from the Northwich district to the alkali-makers at Runcorn. Salt is necessary for the manufacture of washing-soda (which in turn is used for the manufacture of soap and many alkalis) either by the Leblanc or the ammonia-soda process. In the former, brine is treated with Sulphuric Acid, and thus Sodium Sulphate is formed. This substance is converted into Sodium Carbonate, or washing-soda, by being treated with Carbon Dioxide and lime. In the ammonia-soda process (which is cheaper), ammonia is added to brine, which is filtered and cooled and passed into towers and Carbon Dioxide is caused to bubble through them. The crystals of washing-soda which form are dried by heat, while the by-product, Ammo-

nium Chloride, is heated with lime to regain the valuable ammonia so that it may be used again. Calcium Chloride, which is formed in turn, is again probably heated, Professor J. M. Thomson states, to extract the valuable chlorine by a secret process.

Sylvinite

In Alsace, near Mulhouse, there are some interesting deposits of a mineral salt known as Sylvinite, which is mined on a large scale, now, by the French. This mineral is the source of the valuable potash-fertiliser, and contains 35 per cent. of Potassium Chloride associated with rock-salt. This occurs at a depth of 1,600 to 2,300 ft. The deposits, like those in Cheshire, form an ellipse with the longer axis running north-east to south-west, that is to say that the deposits attain their maximum thickness along this line, and thin out to the north-west and south-east of it. Sylvinite exists in two beds of 3 ft. to 8 ft. thick (locally up to 17 ft.) belonging to the Tertiary period. The roof in the mines is formed of hard clay, which renders the workings watertight. The horizontal layers of the salt are coloured in most beautiful shades of red, blue, and yellow, probably due to different percentages of salts which have separated out in the old salt-lake. The concentration of the Potassium Chloride is effected by immersing the Sylvinite in boiling Sodium Chloride brine, which dissolves Potassium Chloride only. This solution is gradually cooled for two or three days, when the Potassium Chloride crystallises out while the Sodium Chloride still remains in the solution as brine, which is used again to treat a fresh supply of Sylvinite. The Potassium Chloride crystals are subsequently dried. Towards the end of the war, an artificial process of extracting Potassium Chloride from the flue-dust from blast-furnaces was instituted for the manufacture of high explosives.

Celestine

A unique but small English industry is that of Celestine-digging. This salt occurs in the Trias at the surface at Yate, in Gloucestershire, and this is the only important deposit in the British Isles. Its commercial value lies in the fact that it contains 90 per cent. of Strontium Sulphate, which is converted into Strontium Nitrate (by Nitric Acid) for the manufacture of fireworks and red flares. Also, another substance made from it, Strontium Hydroxide, attained by roasting the sulphate with coal and iron ore, is used for separating sugar from beet-molasses.

The small white crystals of Celestine are found in masses 2 ft. thick in the red marly clay at a depth of 2 ft. to 10 ft. below the surface. In Sicily, where there are large deposits, these crystals are coloured blue, a fact which gave rise to its name. The deposits are discovered by probing the clay with large iron rods until they strike the stone. A pocket or layer is thus



FIG. 2.—WIELICZKA SALT MINES, GALICIA.
The railway station on the third level.
(By courtesy of Sir Isaac Pitman & Sons, Ltd.)

found and a pit is dug, which gets so large that pumping often has to be resorted to. The Celestine, being comparatively soft, is then picked out by hand, cleaned and stacked in neat square heaps; some 20,000 tons before the war were exported annually to Germany; now the bulk of it goes to the United States. Associated with the Celestine, gypsum sometimes occurs, appearing as a pretty pink, opaque crystallised substance. No systematic method of working has been followed, and the ground is left full of pits and mounds which render it practically useless.

The writer wishes to record his thanks to Messrs. Sir Isaac Pitman, Ltd., for the loan of the photographs showing the ballroom and a railway station in the Wieliczka Salt Mines.

Plant Breeding

By I. B. N.

SYSTEMATIC botanists have marshalled all known plants into divisions and subdivisions of which the "species" is generally the ultimate. But the great total of 140,000 recorded species does not adequately represent the diversity of the plants. Only eleven species of wheat are recognised, but they embrace about 3,000 different kinds or "forms." There are forms with tall straw and forms with short; red grain and white grain forms; early and late ripening forms, and so on in each species through a vast range of differences. New forms of cultivated plants may be introduced into a locality in a variety of ways. They may be brought in from elsewhere; occasionally they arise in nature by processes to be described later; and they can be made from old ones by hybridisation—that is to say, by breeding from two distinct species. They are not always better than the old forms, and careful tests of their merits must be made before they can be recommended for general cultivation. All methods of obtaining and testing forms of crop plants new to a locality constitute the science of plant-breeding.

Scientifically the plant-breeder must try to be "Jack of many trades and master of his own." Like the geneticist, or student of heredity, he must study the laws of transmission of characters from parents to offspring. The geneticist may study those plant characters which are easiest to observe or of greatest scientific interest, but the plant-breeder must deal with those which are of agricultural importance. Of these, in general, the most vital is yielding capacity, the average amount of useful produce furnished per acre. Now the eye is no judge of such a plant attribute as this and definite measurement is essential. We may suppose that a new form of barley has been produced and it is desired to test its yielding capacity in comparison with an old form. If a one-tenth-acre plot of each form of barley were grown, the plots being side by side, and the new gave 15 per cent. more grain than the old, there would appear to be convincing evidence of superiority. But experiment has shown that, if instead of one pair of plots many such pairs are grown, the difference between the forms is not constantly 15 per cent. It fluctuates, and may even sink to zero on some pairs. This inconstancy is attributable to a number of causes. The soil may not be equally fertile on both the plots of a pair; sparrows may damage one plot of a pair more seriously than the other; the incidence of a fungoid disease may similarly be heavier on one plot than another. Actual test shows that a difference in crop between two adjacent one-tenth-acre plots cannot be regarded as significant unless it exceeds 20 per cent. Present-day crops in England have reached a level which makes a sudden yield improvement of 20 per cent. almost inconceivable. An improvement of 2 per cent. is much more probable, and small as this seems, it would, if effected in all the cereal crops of England, increase their annual value by £1,000,000. Methods of detecting such small yield differences have, by degrees, been evolved. The principle is to grow about twenty small plots of every form under test, arranging them so that every form has a plot in every part of the total area of ground employed. Then, if one end of the area be particularly fertile, all forms share the amenity; and correspondingly all forms would suffer together in a part infested by wireworm. The Chess-board Method, as this system is called, permits of the certain detection of differences of 2 per cent.

Other agricultural characters vie with yielding capacity in importance and difficulty. Resistance to disease in potatoes, the bread-making quality of wheat, and the suitability of barley for good beer are examples. Often, not to create, but to appreciate the merits of new forms, is the essence of the problem, and it is impossible to understand either the difficulties or the achievements without a knowledge of the complexity of the agricultural characteristics of plants.

Ornamental plants offer problems demanding an eye for the beautiful and an understanding of popular prejudices. The profusion of forms of tulips, primulas, daffodils, carnations, violas, orchids, and many others, which annually astonish us at the shows of the Royal Horticultural Society, are mainly the favoured survivors of great numbers of new forms raised by hybridisation. It is far easier to gauge the opinion of the gardening public upon a new flower than the value to housewife and farmer of a new potato.

Novelties True and False

"Selection" has been a fertile means of improving crop-plants. It consists in examining single plants in a field, picking out any that appear to be different from the familiar forms, and then making accurate tests when a sufficient bulk of seed has been obtained. The progenies of the original single plants should be kept separate. Chinese cultivators of 3,000 years ago had the germ of the modern selection idea. Some more or less chance selections have proved of great merit. In 1824 a herd-boy, Sandy Thomson, took home an oat-plant he found growing on a heap of ditch mud. His master multiplied the stock and the "Sandy" oat was for many years unrivalled on poor soils in the North. Chevallier barley, perhaps still the best-quality barley and grown in every good barley country, sprang from a progenitor found by a Suffolk vicar in a labourer's garden. But with these stimulating examples a warning must be given. Not infrequently, an unusually fine plant of an old form is hailed as "new" by the undiscriminating or unscrupulous. To this we owe the plethora of synonymous names so familiar in potatoes, cereals, cabbages, and most other crops. The law protects both the name and the manufacture of a flea-powder or a mouse-trap, but offers no obstacle to the theft and renaming of any form of crop-plant. Reputable seedsmen condemn the practice, but it profits the dishonest, for a novelty—the latest pea or potato—sells at a premium. An unwitting purchaser often pays a high price for a form of wheat or other plant which years ago, under its old name, he has tried and rejected. Slender and obscure differences may separate two forms, and proof of identity of the same form under two or three names calls for great critical ability. Recently, samples of different named forms of potatoes were examined by the Potato Synonym Committee of the National Institute of Agricultural Botany. No less than 17 per cent., all bearing different names, were proved to be the familiar form "Up-to-date," and 5 per cent. more were "King Edward." From this auspicious beginning it is hoped that synonym elimination may be extended to all our crop-plants.

Immediate benefit is unlikely now to accrue from the introduction of foreign forms of cereals into England. Unadapted to our climate, they rarely thrive, but although the farmer could not profitably grow them, they may yet have their value. "Little Joss" wheat was bred by Professor Biffen from a Russian wheat of very low yielding capacity, but which was immune to attacks of yellow rust. He crossed it with Square Heads Master—a good cropper, but susceptible to rust—and Little Joss represents a combination of immunity to rust, high yielding capacity, and other valuable characteristics. As far as his resources permit, the plant-breeder ransacks the crops of the whole world for forms possessing features of outstanding merit.

The Importance of Hybrids

In hybridisation lies the great hope of crop improvement. By its means from existing forms new can be derived, and a valuable character, even if associated with others which are undesirable, can be transferred from that association to a different one. The attractive history of hybridisation begins with Joseph Gottlieb Kölreuter, who about 1750 first demonstrated that seed-formation was a sexual process and effected the first artificial hybridisation. His successors improved the technique and amplified the field of work. Towards the end of the eighteenth century Thomas Andrew Knight raised great numbers of new forms of plants, including garden peas and the fruits. Two brothers, John and Robert Garton, founders of the present seed firm, Gartons, Ltd., commencing in 1890, produced a great succession of new forms of cereals. But the greatest of the pre-Mendelian plant-breeders was William Farrer. To benefit his health he went to Australia after going down from Clare College, Cambridge, and originally as an amateur, devoted himself to wheat-breeding. Most of his predecessors optimistically clung to the belief that from continual hybridisation, especially with widely different parents, there must emerge some wonderfully superior novelty. With an insight which gave him an appreciation of one aspect of Mendel's then dormant discovery, Farrer perceived that valuable forms could be bred only from parents themselves possessing specific desirable characters. Choosing his parents from Europe, India, and America, he systematically aggregated into new wheat forms the characters requisite for the diverse conditions of Australia. His great services have their monument in the present wheat-growing industry of the Commonwealth.

The Secret of Successful Breeding

Mendel's discovery, like Kölreuter's, opened a new chapter of history and, since modern plant-breeding is based upon it, it deserves our respectful consideration.

A seed is formed from two small bodies called reproductive cells or gametes. One of these, the male gamete or pollen grain, is from the male organs of the flower; the other, the female gamete or ovule, is from the female organs. A pollen grain, entering and combining with an ovule, brings about the conversion of the ovule to a seed. To hybridise or make a cross between two parent plants, it is necessary to remove the male parts of the flower of one of them and to place upon the untouched female parts some pollen from the

other. To keep out wind- or insect-borne pollen from other plants, the flower which has been thus treated must be covered with fine muslin or a greased-paper bag. The seed resulting from this act of artificial hybridisation grows into a plant called the F_1 (first hybrid generation). This, by fertilising itself, produces seeds, and these grow into plants collectively called the F_2 generation. From the seed of every F_2 plant a family of plants (F_3) may be raised. The original parents are designated F_0. That the form of the F_1 and the proportions of different forms in F_2 were governed by precise laws was the essence of Mendel's discovery.

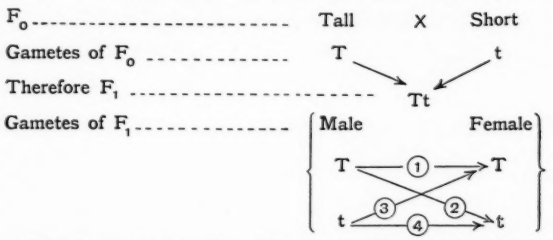
In 1866, just before he became Abbot of the Augustinian house at Brünn, Mendel communicated his discovery, actually made in 1859, to a local scientific society and by letter to some botanical contemporaries. All failed to appreciate his work: the *Origin of Species* published in 1859 had still a monopoly of biological attention. Fortunately in 1900, through a brief reference in a book, the discovery was unearthed. It was immediately confirmed and enthusiastically received. Mendel had died sixteen years previously. His laws may be thus briefly stated.[1]

All plant characters are in pairs, the members of a pair corresponding to the presence and absence of a Mendelian "factor." In garden peas tallness and shortness are such a pair. The F_1 plant from the cross Tall × Short is found to be tall. Consequently tallness is said to be the "dominant" character and shortness the "recessive." The dominant character results from the presence in the plant of the factor for tallness, the recessive from its absence. From the seeds formed (by self-fertilisation) by the F_1 plant, there develop a number of plants (called the F_2 plants), some tall and some short, there being 3 talls to 1 short, i.e. a proportion of 3 : 1. Of the 3 talls, 1 (i.e. a third of the total number of talls) breeds true, all its progeny being tall. The remaining 2 talls, when self-fertilised, behave exactly like the F_1, their progeny being in the proportion 3 talls to 1 short. The shorts of the F_2 breed true for shortness (i.e. their progeny consists solely of short plants). Thus the F_2 falls into three types:

1 tall (breeding true); 2 tall (giving tall and short in their progeny); 1 short (breeding true).

The proportion 1 : 2 : 1 remains constant however often the experiment is repeated. This constancy is the first salient feature, and Mendel's laws afford an explanation of it in the following terms:

The tall parent (F_0) introduced the factor T for tallness, while the short parent (F_0) lacked it. Absence of the factor may be denoted by t. When the gametes of the F_0 plants combined, they formed a seed of constitution Tt. From this the F_1 plant grew, having, of course, the constitution Tt. Mendel argued that of its gametes, male and female alike, exactly a half possessed the factor for tallness (to be denoted therefore by T) and the other half lacked it (denoted by t). When it became self-fertilised by the union of its own male and female gametes, the two types of male gamete must have combined with the two types of female gamete, giving four types of seed. Thus T male with T female = TT seed; T male with t female = Tt seed; t male with T female = Tt seed; t male with t female = tt seed. The seeds formed by F_1, and thus the F_2 plants into which they grew, must therefore be expected in the proportion 1 TT : 2 Tt : 1 tt. Of these F_2 types TT will breed true on self-fertilisation, since it can contribute only T to all its gametes, male and female. Similarly the tt must breed true. But the 2 Tt will, like the F_1 (also Tt), give a 1 : 2 : 1 ratio in their progeny. This prediction accords precisely with the experimental result described above. A diagrammatic representation may be given.



(The arrows indicate the different possible combinations of male and female gametes.)

$$\text{Therefore } F_2 = \overset{1}{TT} + \overset{2}{Tt} + \overset{3}{Tt} + \overset{4}{tt}$$

i.e. 1 TT : 2 Tt : 1 tt.

Plants of constitution Tt which, when self-fertilised, do not breed true, but in their progeny "split" off different types, are called "splitters." In botanical language they are "heterozygous" for T; forms like TT and tt are "homozygous."

Crosses in which the parents differ in more than one pair of characters illustrate Mendel's second law—pairs of characters are inherited independently of one another. Suppose that in the cross discussed the tall parent had "round" seed and the short had "wrinkled." Round and wrinkled may be denoted by R and r, for experiment shows that they are a pair of characters and that round is the dominant. To foretell the results of the cross, it is simply necessary to apply the principles explained for T and t above jointly to both pairs of characters. All possible types of gamete will be formed in equal proportions and all possible combinations of male and female gametes

[1] *Heredity*, by L. Doncaster, Cambridge Manuals of Science and Literature, is a simple and attractive little book for those who seek further information about Mendelism.

will take part in the formation of seed. Simple mathematics enable the following scheme to be drawn up:

A Cross between Two Parents which differ in Two Pairs of Characters.

F_0 . . . Tall Round seed × Short Wrinkled seed

Gametes of F_0 . TR tr

Therefore F_1 . . . TtRr

Gametes of F_1 . Male: TR, Tr, tR, tr; Female: TR, Tr, tR, tr

Therefore F_2 =

	TTRR*	TTrr*	ttRR*	ttrr*
	2 TTRr			
	2 TtRR	2 Ttrr	2 ttRr	
	4 TtRr			
	9 :	3 :	3 :	1
Containing	T and R	T but not R	R but not T	Neither T nor R.
Therefore	Tall and Round	Tall and Wrinkled	Short and Round	Short and Wrinkled

Here the ratio of forms in F_2 is 9 : 3 : 3 : 1 and is always the same for this cross. For T and R independently the ratio is, as before, 1 : 2 : 1, e.g. forms with RR : forms with Rr : forms with rr = 4 : 8 : 4 = 1 : 2 : 1.

The forms marked * are the only ones homozygous in both pairs of characters, and therefore they alone will breed true to both. Of the remainder some, e.g. TtRR, are homozygous for one pair and one, TtRr, for neither. For crop production only true-breeding forms are acceptable, i.e. forms homozygous in all character pairs, for they alone will remain unchanged. The forms of ttRR and TTrr are completely homozygous and are different from both the parents (F_0). They are thus examples of new forms from old ones. Where the F_0 differ by 3, 4, . . . pairs of characters precisely the same principles apply, and it will now be realised how, by choosing suitable parents, we can theoretically synthesise any desired combination of characters.

There are two great limitations to this alluring theoretical possibility. Plants will not intercross at random. Generally, different forms of the same species present no difficulty. But we often desire to combine the characters of two different species. The attempt has many times been made. In some cases no hybrid seed is formed; in others an F_1 plant is obtained but, like the mule, is sterile; in yet others the F_1 produces some seed, but most of it fails or develops into sterile F_2 plants. It seems improbable that new and improved crop-plants will be obtained from inter-species crossing, but many forms of violas, saxifrages, roses, irises, and pinks have been obtained in this way, while among the orchids even inter-generic crosses have succeeded. Strange to say, wheat and rye are partially inter-fertile.

"Linkage" is a phenomenon which imposes the second limitation to the welding together at will of plant characters. This in effect is a tendency of two pairs of characters to cling together, so that in the F_2 of a cross there is not the uniform assortment of character combinations which was described above for unlinked characters. Certain combinations may appear in F_2 only in the proportion of, say, 1/1,000 or even not at all. Linkage is an exception to Mendel's second law which he himself never encountered.

Mendelism and the Farmer

The British farmer grows many plant forms of hybrid origin. He does not always realise this, and when confronted with an admitted product of methodical hybridisation often asks, "Will it hark back?"—i.e. will it in time revert to the form of its less valuable parents? If the work has been well done. if the new form is homozygous in all characters, the answer is an emphatic No. Such a form, if protected from foreign pollen, will continue to breed true. Plant forms, whether natural or derived from artificial hybridisation, homozygous in all characters to start with, and safeguarded from natural cross-pollination, are called "Pure Lines." Being immutable, they cannot be improved by selection. For a hundred years past, and even to this day, time and effort have been vainly spent in attempts to improve pure lines by selection. The most common fallacy has been that the continued selection year after year of the largest seeds must "improve the type." But careful experiment has shown that if, year after year, the largest and the smallest seeds of the crop of a pure line are separately selected and grown, the resultant plants are the same. Commercial stocks of seed often contain five or six different pure lines, and selection will separate these out but can do no more. Catalogues often expatiate on "Jones's re-selected variety." At the best this can only be a stock free from admixture with other forms. Such a stock is valuable, but not always to the extent of the enhanced price demanded.

The immutability of the pure line has one exception. Among the most carefully safeguarded stocks may be one or two plants different from the type. They are called "mutations," and arise from the original form by some as yet inexplicable process of nature. Mutant buds occur on some trees and may be propagated by budding on to a suitable stock. Mutations are exceedingly rare, and accidental admixture of seed or natural cross-pollination is not infrequently the cause of their reported occurrence.

In many minds the comparative simplicity of the

fundamentals of Mendelism obscures the complexity of the plant-breeder's task. He chooses two parents for their desirable characters, crosses them, and endeavours to secure from the progeny a form which combines the best features of both. In a simple case he obtains an F_2 of, say, 1,000 plants without much difficulty. Parents differing in four or five pairs of characters will give a considerable diversity of types in F_2, and in all probability there will be a number of more recondite parental differences which escape observation and reinforce the complexity of the inheritance. By what tests may the best forms be detected? Will the form which excels as a single plant still be the best when millions of its descendants are grown crowded together in the field? Are the best-seeming forms homozygous in all characters? These are the inevitable puzzles. Judgment and experience can alone attempt to solve them. As yet, unaided, pure science cannot assess the agricultural characters of plants, particularly of single plants. In principle it would be quite simple to sow the seed of every F_2 plant and thus obtain an F_3 family, and from this the F_4, F_5 . . . could be grown. In every generation there is increased material on which to base judgment. This is all to the good, but increase in material means increase in ground-space and, above all, in time and attention. To prevent the accumulation of impracticably great numbers of plants—and a single plant of wheat may in five years give rise to 100,000—elimination must begin early and become more intense in the successive generations. When some twenty forms remain, a chessboard trial of yield is conducted, tests of other characters—e.g. of baking quality in wheat—are made, and usually only one form is finally retained. This is tested against well-known forms on a field scale, and if found to be an improvement on them, is placed upon the market. The production of a really satisfactory form on these lines must occupy not less than ten years, and fifteen is the probable number. Many new forms are brought to market with inadequate testing in a far shorter period. They enrich the producer—as do most "novelties"—have their short day, and disappear. Others follow in monotonous but profitable succession: the farmer is the victim.

It is well known that the F_1 plant may in some cases be far more robust than either of its parents. This so-called "hybrid vigour" is a complex phenomenon and may be displayed only in height and abundance of foliage, there being little or no seed produced. But ingenious minds, arguing from these cases that the act of artificial hybridisation is responsible for increased "vigour," have conceived a new procedure. Two plants of precisely the same form, and which normally would produce seed by self-fertilisation, are artificially crossed. From seed so obtained there grow plants called "regenerated" plants, and from these stocks of "regenerated seed of existing forms" are placed upon the market at enhanced prices. Such "regeneration," if a real phenomenon, is at present unknown to science. It is noteworthy that in a careful test of the yielding capacity of a form of wheat from ordinary seed, and from seed "regenerated" in the manner described, there was absolutely no indication of yield increase through "regeneration."

"England's premier wheat" (or cabbage, etc.) is the recommendation sometimes bestowed on a form newly marketed. It is misleading. Our country, small as it is, has many different soils, and is afflicted by great annual climatic variations. No plant form, among the common crop-plants, is every year, and in every place, better than all the others. Instead of claiming or attempting to breed this master-form, the aim must be to ascertain as closely as possible the special environmental features of the different parts of the country and to find or breed the plant forms best adapted to them. Of the known forms of wheat, barley, potatoes, etc., none is better than all others in every part of England, and in a single county one form may excel in the east, a different one in the west.

The Berber Tribes of Morocco

By E. Gurney Salter, Litt.D.

"THE world is a peacock, Morocco is its tail."

So runs the native proverb, voicing the naïve patriotism of those to whom "the world" probably means at most Moslem North Africa, from east to west. But, indeed, Moghreb-el-Aksa, the "farthest west" portion of this world, with its natural beauty and rich endowments, stirs the enthusiasm of European visitors, now that the motor and the aeroplane are invading its secular inaccessibility.

In descriptions of the triumphant progress of French colonisation in the Protectorate, or of the recent severe reverses suffered by the Spaniards in their northern zone, allusion is frequently made to "the tribesmen" of Morocco, or tribes are mentioned by name. Raisuli's stage-bandit career is nearly as well known as Captain Macheath's.[1] But, in general, ideas about these tribes are rather vague, and it is hoped that the present article may throw a little light on some characteristics of the Berbers, who are quite the most interesting, as well as the enormously preponderating race in the

[1] Those readers who have witnessed the recent revivals of *The Beggar's Opera* and *Polly* will be well acquainted with this delightful villain.

country. In some districts they have become more or less completely fused with Arabs and Arabic is spoken as well as the Berber tongue, or has even superseded it, but in others the primitive race and tongue still persist.

The remaining peoples of Morocco (other than European settlers) may be briefly summarised as follows: the Arabs, descendants of Arab invaders in the eleventh and following centuries; the Moors, a name that, strictly speaking, should be confined to the mixed population, largely Berber in origin, of the ports and other towns who are descendants of the Moors expelled from Spain; the Jews, who live in a ghetto (*mellah*) in certain towns, and travel about as traders, interpreters, etc.; they are despised, rather than actually ill-treated; the negroes, formerly imported in great numbers from the Sudan as slaves; and the *harratin*, a negroid race, varying from brown to black in colour, possibly half-castes, possibly a distinct race, who are largely employed as agricultural labourers.

The Berbers themselves are in origin essentially a white, Mediterranean race, with whom a brown Saharan race would appear to have mingled. They are often deeply bronzed by the sun, and black-haired; north of the Atlas, e.g. in the Rif, a distinctly fair type is found, with reddish hair and blue or grey eyes. Some Berbers in the south-west of Morocco are as black as negroes, and are rather despised by the others in consequence. The Moroccan Berbers are, of course, akin to the famous Tuaregs and to some Algerian tribes (e.g. the Shawiya). They call themselves Imazighen (= noble), and the name of their language (*Tamazight*) is derived from the same word. They are a virile race of fine physique; fanatical lovers of liberty, casual in religious observance (when they take up arms it is far more in defence of their independence than as a "holy war" against the infidel), but appallingly superstitious; shepherds and agriculturists, scorning trade. They have democratic institutions peculiar to themselves, of which we shall speak later.

Three main groups of Berbers may be distinguished in Morocco: (1) the *Ruafa*, or tribes of the Rif, i.e. the eastern portion of the Spanish zone along the Mediterranean; these of old furnished the redoubted "Barbary pirates"; they speak a dialect of Tamazight known as *Tarifit*, or in some parts as *Zenatiya*; (2) the *Shluh*, of the western or south-west districts (the Sus, Southern Atlas, Marrakesh, etc.), speaking another of its dialects called *Tashilhait* (arabic, *Shilha*), and often Arabic also; (3) the *Beraber*, of the Middle and High Atlas, extending northward to the Franco-Spanish frontier and southward to the Tafilelt,[1] with outlying groups in the west. Their dialect is known as *Taberberit*. The Beraber are the most formidable and numerous group of Berbers, and the least arabised or subdued. Several of their tribes have not yet made their submission to the French. They do not form a political unit, though there are two or more powerful confederations of tribes among them; the unifying factors are their language and central position. Very few Jews are found in their territory.

Each of these groups consists of a great number



FIG. 1.—A WAYSIDE SCENE.
(By courtesy of the French Protectorate Government in Morocco.)

[1] This is the Berber form of the name of the famous date-palm oasis, in Arabic, *Tafilalet*.

of tribes (*kebila*),[1] which, in their turn, have innumerable clans or divisions, and subdivisions. There are leagues among tribes (*leff*) and alliances of groups or factions within a tribe (*soff*). Estimates as to their numbers vary so greatly and are based in many cases on such insufficient evidence that they are hardly worth quoting. Many of the Atlas tribes are as yet very little known. The French are collecting statistics, and are encouraging the study of Berber dialects and folklore. Tamazight is little used for writing purposes, the Berbers being mostly illiterate ; the Arabic alphabet is employed. The education and development of the Berber and mixed Berber-Arab tribes offers the best hope for the future of Morocco, the local Arabs being more or less effete, and decadent. Arabic influence in the country has been chiefly shown in the spread of their language and religion, and the introduction of the hosts of sherifs (*shurfa*), or descendants of the Prophet, of whom the Sultan himself and Raisuli are both representatives. These sherifs enjoy an enormous prestige, and often wield considerable power. A notable example is that of the sherif clan of the " sacred city " of Wazzan, heads of the Tuhama Confraternity. The position is so much coveted that some Berbers, ignoring their non-Arabic birth, have laid claim to it !

Equally venerated is the *marabut*, or holy personage, male or female, sometimes the founder of an Order, or religious house (*zawiya*) ; sometimes an ascetic or ecstatic, a miracle-worker, or simply a madman. The word *marabut* is also applied by local Morccan usage to holy places and things, such as shrines, tombs of saints, trees, or even heaps of stones.

The Berbers, who apparently adopted Islam in easy-going fashion, are equally easy-going in its practice. They are for the most part uninstructed in the Koran, and disregard its precepts as to prayers, ablutions, and fasts. Even Ramadan is ignored. Boar's flesh is eaten, and a liquor manufactured by the Jews from grapes or figs is drunk, not, however, to excess, sobriety being the usual rule among Berbers. Many traces of pre-Islamic superstitions are found ; they live in terror of demons, spirits, werwolves, and the like. Talismans are worn, and local saints are invoked, against these, the Kadriya Confraternity being considered specially efficacious in exorcisms. Most males in Morocco, Berber or Arab, are enrolled in one or other of the various Confraternities, or Orders ; these cannot be discussed here, but it may be remarked that they were not political in origin, though they have often been diverted to political ends. The Shluh of of the Sus district have a great reputation as sorcerers. The Ihahen (Arabic, *Haha*), a large Berber tribe, or rather group of tribes, on the west coast, cherish a firm belief in a mascot. A certain individual, or family, known as *anflus*, must necessarily take the lead in any tribal undertaking, whether a journey or a battle, if success is to follow. Great prestige attaches to the post.

A regular ritual is observed among the Berbers in connection with agriculture and the promotion of fine weather, with marriage and other family events.[2]

Any allegiance that the Berbers have yielded to the Sultan (there has been remarkably little trace of it) has been to his religious position. In his political capacity, he and his government, the Maghzen, have been consistently defied. The Shluh round Marrakesh have proved relatively amenable, but, everywhere else, Berber territory has been emphatically *bled-es-siba* (land of gunpowder, i.e. rebellion). The tax-collector has returned empty-handed, or not returned at all, while short work has been made of any *kaid* or *sheikh* whom it was sought to impose on a tribe from outside. There is a rude proverb somewhat to this effect : " A strong tribe can soon spit out a *kaid*." With certain exceptions, to be noted later, the *kaids* of the Berber tribes have very little power ; some of the wilder mountain tribes are said not to tolerate them at all. The Berbers are, in fact, notably independent and democratic ; three of their most interesting features are their codes of customary laws, their government by a popular assembly, and the position allotted to women among them.

The popular assembly (*anfaliz* ; in Arabic, *jemaa*), has all the real power in its hands ; it decides all the affairs of the tribe—peace, war, alliances, markets, and so forth. It consists of all the males of fighting age ; the voice of the elders (*amghar*) carries great weight, and women are also called into consultation. One elder is chosen annually to execute the decisions of the council and is known as the *amghar-el-aam*. Great jealousy is felt lest any power should become hereditary. In time of war, the Beraber call together a general assembly of delegates from all their tribes, one of whom is elected as dictator (*amghar afella*)—his powers, again, being strictly limited to one year.

The Berbers are monogamous, and fond of their children and homes. Women, though hard-worked, are respected and consulted, and go about freely. Marriage is more or less of a sale, but sexual morality is higher (especially among the Ruafa and Beraber) than among the surrounding Arabs. Women have the privilege of affording protection (*anaya*) to suppliants in danger of their life. A safeguard, usually known as *zettat*, is also given to travellers passing through the territory of one tribe, or into that of an allied tribe, or clan, while some powerful tribes protect weaker ones in return for tribute. Certain tribes are also

[1] Singular ; so also the two following Arabic words.

[2] See Westermarck's books on these subjects.

recognised as the special protectors of holy places, but this does not prevent their looting them when funds run low! The Ait[1] Atta, for example, the most redoubtable Beraber confederation, not long ago sacked the "sacred city" of Tamgrut, on the Draa, which was under their ægis.

The exceptions referred to above as to government by *kaids* are the four great kaidates of the Atlas—Glawa, Gundafa, Mtuga, and Menaba—with some others on the western coast. These Atlas *kaids* remarkably resemble mediæval barons, and rule their peoples in feudal style. The two first, who are much the most important, dwell in crenellated fortresses of striking architecture, unlike other buildings in Morocco, possibly Phœnician in origin. They are only nominally antagonists for European troops, alike in their own land and on the fields of France and Flanders. For many years, in spite of attempts to stop them, they have been smuggling in European arms (e.g. Gras and Martini rifles) and gunpowder, to supplement or supersede their native-made flintlocks and powder, their primitive curved daggers and billhooks. Whole villages or tribes have clubbed together to buy rifles, and regular firing-practices are held. During the Great War, to the discredit of Spanish neutrality, German arms and military instructors were allowed to pass freely through the Spanish zone—an action which has recoiled on the heads of the ill-fated Spanish troops in the late campaign. On several occasions in the past, the tribesmen have only yielded to heavy



FIG. 2.—AN OLIVE PRESS.
(By courtesy of the French Protectorate Government in Morocco.)

viceroys of the Sultan, really independent, and all-powerful in their part of Morocco. The heads of the Glawa have been loyal allies of the French, and the chief maintainers of order in the south in troubled times. Among the other *kaids* having more than usual power are those of the Abda and Ihahen (*Haha*) tribes; the jealous rivalry between two *kaids* of the latter involved their clans, not long since, in protracted warfare.

Martial Prowess

The Berbers make fine soldiers, daring, skilful, and capable of endurance. They have proved formidable artillery, but some of them have apparently now captured and learnt to use this themselves. The Berbers are skilled in cavalry tactics, and in sieges and ambushes; they are good shots at short range, and have, naturally, a great advantage in their intimate knowledge of the difficult country in which operations are carried on.

It must, unhappily, be recorded that, with all their fierce courage, they are also cruel, treacherous, and vindictive, and so greedy for loot that they will plunder their own fallen comrades. Avarice is, indeed, somewhat surprisingly, one of the chief vices of the Berbers. Inter-tribal or inter-divisional hostilities are frequent; the possession of coveted watering places is fought for, or the hidden granaries (*silos*) of enemy tribes raided and their villages destroyed.

[1] *Ait* is a Berber collective term, equivalent to the Arabic *Beni*, or *Ulad*, i.e. children (or people) of . . .

Agricultural Pursuits

The Berbers exhibit every stage of pastoral life, nomad, semi-nomad, and sedentary. They own enormous flocks and herds (sheep, cattle, camels, and in the south, ostriches), and vast palm-groves in the Tafilelt. Many of the coast tribes are fishermen. Most of the Shluh tribes lead sedentary lives, and are great cultivators, their land being very fertile. The rich black soil (*tirs*) of the western districts bordering on the Atlantic produces, even with primitive agricultural methods, three, or as many as four, crops a year, while the grains of corn on each spike have been known to average eighty or more. The cattle of the Zaer and Zayan tribes of this region are famous. When scientific methods of farming and cattle-breeding have been more widely spread by colonists, there seems no limit to the results that may ensue ; the true wealth of Morocco may probably turn out to be here rather than in its alleged mineral resources.

In this same district (western Morocco, south of the River Tensift), and peculiar to it, is found the argan-tree, or "Barbary almond" (*Argania sideroxylon*) ; and the tribesmen extract an inferior oil from the kernels of its fruit. Olives and walnuts, vines, figs, and other fruit-trees are cultivated along the river-banks ; the mountain villages are pink with almond in spring, almonds being one of Morocco's chief exports, and olive-oil one of the few manufactures of the Berbers.[1] The magnificent cedars of the Atlas have, unhappily, suffered greatly from unskilful hacking by the natives. Patches of beans, peas, onions, and other vegetables are grown wherever possible, vegetables, with maize, forming the staple article of food. Meat is rarely eaten, and eggs, for some reason, are shunned ! Seasonings, such as pepper and spices, are beloved, and the favourite drink is weak tea overflavoured with mint or sugar.

The men wear the *jellaba*, or loose, hooded wrap, with the toga-like *haik* ; women also wear the latter, under a simple length of cotton wound round and round them, known as *lizar*. Red or yellow leather slippers are usual. In the western Atlas, a short, dark woollen wrap, ornamented with orange or scarlet, is worn. Blue cotton clothing (*khent*) is universally worn in the south. The dye from this comes off on unwashed bodies, hence the name, "the blue men of Mauretania," given to a band of religious agitators, who for some years created disturbance in western Morocco from south to north. Berber women are addicted to wearing heavy earrings, and in many tribes both they and the men are tattooed.

The nomads live in tents grouped in villages, the settled villagers either in houses of stone or pisé, or in huts of earth and branches. The tent village is called *duar*, the ordinary village *deshra*, or, if fortified, *ksar*. Each village usually has a fortified depôt (*tighremt*) for arms and grain ; except among the Shluh, where such depôts are tribal, and are known as *agadir* (plural *igudar*). Such is the origin of the world-famous port, storm-centre of the 1911 crisis ! (Its full name is Agadir Ighir, i.e. the fortified place on the hill.) Many of the villages are called after the weekly market (*suk*) held in them—a most important feature in tribal or sub-tribal life, inasmuch as they offer occasions for spreading news, fostering risings, or the like. These markets are held on different days of the week. Thus, to take one instance, an important centre in one tribe is known simply as Jemaa Entifa, i.e. the Friday market of the Entifa. There are also several well-known annual fairs, attended by all the tribes round ; these have sometimes a semi-religious character.

To these villages and these clusters of tents the French administration, inspired by Lyautley, is gradually bringing order and civilisation. Native schools are established and medical succour afforded by travelling doctors and dispensaries. Tribal customs are, where possible, respected, and tribal administration preserved, under supervision. The happy results of this "peaceful penetration" are already so evident that it may be hoped the system will be copied by Spain in her zones of occupation. Without losing any of their fine qualities, but rather developing them to the full, the Berbers must be taught to live at peace among themselves ; on them hangs the well-being of Morocco.

[1] Others are rough pottery and leather-work.

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Among the Stars
A Monthly Commentary

A Famous Modern Astronomer

MUCH of the recent progress in astronomy is associated with the name of Dr. Harlow Shapley, Director of the Harvard College Observatory, Cambridge, Mass., U.S.A., who has within the last few years attained to one of the highest positions in the scientific world. A few biographical notes concerning this distinguished astronomer are therefore not without interest. Dr. Shapley is a native of Nashville, Missouri, where he was born on November 2, 1885. In 1907 he entered the University of Missouri, where he took the degrees of A.B. and A.M. In 1911 he proceeded to Princeton in order to follow the study of astronomy, and during his three years' period of research in the University there he came under the influence of Professor H. N. Russell, and in 1914 graduated Doctor of Philosophy. In 1914 he joined the staff of the Mount Wilson Observatory, and in the same year commenced his monumental *Studies based on the Colours and Magnitudes in Stellar Clusters*. These investigations, of which the results are summarised in the contributions from Mount Wilson Observatory, dealt not only with clusters, but with the structure and extent of the visible universe, the distances of various classes of celestial objects, and problems of cosmogony. In 1921 Dr. Shapley was called to Harvard to succeed Professor E. C. Pickering as Director of the famous Harvard College Observatory. Since his marriage in 1914 he has had the invaluable assistance of Mrs. Shapley, who is herself a distinguished astronomer.

The Distribution of the Red Stars

One of the latest of the numerous important circulars issued from Harvard under Dr. Shapley's inspiration deals with the distribution of the red stars. These stars were ranked by Secchi in his famous classification as of the third type, and in the Draper Catalogue they are known as Class M. The class is divided into four subclasses, M*a*, M*b*, M*c*, and M*d*, and of these the M*d* stars are the long-period variables. "Practically all the Class M stars in the Henry Draper Catalogue," says Dr. Shapley, "are giants. This conclusion can be reasonably deduced from what is now known of the relative frequency of giants and dwarfs among stars brighter than the ninth magnitude. The high luminosity of these stars is also evident from characteristics of their spectra." The distances of the "invariable class M giants," as Dr. Shapley calls the typical red stars, are easily computed when the apparent brightness is known; and from the relation between apparent magnitude and distance, it is possible to fix the positions in space of four thousand red giants. Of the stars brighter than the eighth magnitude, Dr. Shapley finds that stars of the sub-class M*b* show no concentration to the galactic plane, i.e. are scattered equally over the sky, while the M*a* stars are more numerous by 30 per cent. per unit area between galactic latitudes -10° and $+30^\circ$ than elsewhere. For stars fainter than the eighth magnitude, both classes M*a* and M*b* are strongly aggregated towards the plane. This is a highly important result indicating that the fainter stars belong to the Milky Way clouds, while the nearer stars are more or less members of the local cluster. Dr. Shapley also finds that stars fainter than the eighth magnitude are much more numerous in the direction of Sagittarius than in the opposite region of the sky. This may be due to the better quality of the plates used at Arequipa—the southern station of Harvard College Observatory—for photographing the southern skies. "But it may be largely explained by the greater real depth of the Milky Way in the direction of Sagittarius. The greater frequency in that direction is already established for planetary nebulæ, novæ, and other types of highly luminous stars." In the case of the long-period variable stars of class M*d* it has been found that in the direction of Taurus there is but one-half the average number, and in the direction of Sagittarius there is twice the average number; while the fainter stars of the other three sub-classes are much more numerous in the same direction. These results are strongly confirmatory of Dr. Shapley's theory of the structure of the Stellar System, and of his contention that our Solar System is near the centre, not of the general galactic system, but of a local cluster, and that the real centre of gravity of the whole system lies amid the dense star-clouds of Sagittarius.

The Light Changes of Beta Ceti

It will be remembered that in the end of February last, Mr. Abbot, a young Englishman resident in Athens, announced that the star Beta Ceti had suddenly increased in brilliance. At the time of the announcement, the constellation Cetus was becoming rapidly invisible in the sunset twilight, and confirmation was difficult to obtain. In a paper published in the *Monthly Notices* of the Royal Astronomical Society, however, Professor A. D. Ross, of Perth, Western Australia, states that his observations under excellent meteorological conditions clearly indicate an increase in brightness. "There can be no doubt," he maintains, "that a remarkable disturbance took place in the star prior to March 1." The brightness decreased steadily until March 4, "after which there appear to be fluctuations with a period of about five days." Beta Ceti has never been known to be other than a normal, steady star, and this sudden outburst is extremely puzzling. The star is situated at a considerable distance from the galactic plane, where outbursts of the kind are relatively frequent. The spectrum of the star is of Harvard type K: that is to say, it is a yellow star, not very dissimilar to the Sun in physical condition.

The Recent Solar Eclipse

Astronomers have been much disappointed by the reports from the various expeditions sent out to observe the total eclipse of the Sun on September 10 last. Professor Campbell states that the Lick Observatory Expedition was frustrated by a densely clouded sky throughout the whole period of totality. Fifteen other expeditions

in California and Mexico experienced similar misfortune. One party located in Central Mexico was more successful and was able to observe a portion of the total phase.

HECTOR MACPHERSON.

Reviews of Books

Botany. A Junior Book for Schools. By R. H. YAPP, M.A. (Cantab.), Mason Professor of Botany in the University of Birmingham. (Cambridge University Press, 3*s.* 6*d.*)

All who are interested in the teaching of Botany to beginners should make a point of securing a copy of this excellent book. It is admirably suited to the purpose for which it was written; in particular the clear and careful original drawings, and the well-thought-out scheme of practical work, deserve mention. The standard is that of the Junior Local Examination of the University of Cambridge. R. J. V. P.

Essays of a Biologist. By JULIAN HUXLEY. (Chatto & Windus, 7*s.* 6*d.*)

Mr. Julian Huxley is not only the inheritor of a famous name; he also possesses gifts of style and skill in presentation of his arguments that were the hall-mark of his famous ancestor. He has a deep interest in the borderlands of science and philosophy, biology and theology which were always fascinating his grandfather and brought him into sharp contact with leaders of thought in his day. DISCOVERY cannot follow the author into his discussions with theologians who have much to say on the conclusions he has reached. There is less misunderstanding nowadays than there was half a century ago, and it is well to have laid down clearly that a "law of nature is not something revealed, not something absolute, not something imposed on phenomena from without or from above; it is no more and no less than a summing up, in generalised form, of our own observations of phenomena; it is an epitome of fact, from which we can draw general conclusions." Our "laws of nature" are entirely dependent on our knowledge of the facts of nature, and we can claim no finality for these laws. Conclusions drawn from laws have in their last resort to appeal to facts to verify them. Science, when it goes beyond facts and deals with processes and ultimates, has to call in the aid of philosophy and theology, and we excuse ourselves from dealing here with the great questions that are raised by our author in his concluding Essays. They have their weight coming from a man who has carefully studied the subject, but they are by no means universally accepted by scientists. Theologians reject them even when they are men of scientific attainments, and philosophers are not of one mind on them.

In his *Essay on Progress* Mr. Huxley breaks a lance with Inge and Bury, who deny the existence of a law of progress. We think that they are not so much in disagreement as may appear. Has the mind of man in historic times increased its capacity to achieve more with the material at hand than in the past? We have seen the Golden Age of Athens and its fruits have never been surpassed, and the fact that man has capabilities greater than those beings lower in scale of evolution does not imply that man possesses the further capability of progress which would prove the contention of our author. Here we have to make the usual induction of facts from which a law of progress has to be deduced, and it is at least an open question whether Inge and Bury are not as right in their view as Mr. Huxley believes himself to be in his. Closely connected with this Essay is the following paper on *Biology and Sociology*, in which he shows not only the difference but the natural connection between pure biology and sociology. Man is capable of ideas and of transmitting his ideas to such an extent that "the experience of Moses, Archimedes, or Charlemagne, of Jesus, Newton, or James Watt is modifying our behaviour to-day."

The paper on *Bird Mind* is fascinating and attractive. Mr. Huxley acutely observes and as delightfully describes his observations. The pages describing the courtship of the Grebes may be placed, without suffering in comparison, by the side of Maeterlinck's famous passages on the Bees, and here we have Mr. Huxley at his best. *Sex Biology and Psychology* contains sound criticism on many current theories, and we are glad to read his protest against the indiscriminate use of psycho-analysis. *Philosophic Ants* bases a series of reflections on the Ant-republic under the influence of heat. We have already referred to the concluding papers, which are *Rationalism and the Idea of God* and *Religion and Science: Old Wine in New Bottles*, and we take leave of a suggestive and informing volume by quoting its closing words: "That moulding of matter by spirit is, under one aspect, Science; under another, Art; under still another, Religion. Let us be careful not to allow the moulding forces to counteract each other when they might co-operate." To do this it is necessary to understand the limitations of Science, Art, and Religion. T. J. PULVERTAFT.

Practical Plant Ecology. A Guide for Beginners in the Field Study of Plant Communities. By A. G. TANSLEY, M.A., F.R.S. (7*s.* 6*d.*)

This book is intended "as a guide for those who are attracted to ecological work, but are uncertain as to how to set about it." The study of plants and animals as they exist in their natural homes or, as the author happily puts it, the investigation of their household affairs—that is what Ecology means—is a branch of biology which has made rapid progress in recent years, and many botanists have devoted themselves to this difficult and fascinating pursuit. One difficulty has been the lack of a satisfactory guide. Formerly botanical excursions were mainly devoted to collecting and naming plants and searching for new localities: we have now gone beyond that stage. Ecology does not supplant systematic botany; a basis of sound systematic knowledge is essential; but the ecologist must also be a plant physiologist. His aim is to learn as much as possible about the actual life of a plant, why it grows in one place and not in another, why certain plants usually grow together; in short, he sets himself the task of going to the root of the matter, not

only in the literal sense of inquiring into the relation between the root-system of plants and the ground from which they obtain most of their raw material, but in a figurative sense. His aim is to learn all that is possible about the manifold factors which govern the life, the wanderings, and the interrelations of the component elements of vegetation.

In Part I the author explains what Ecology is; he draws an apt comparison between ecology and the study of man: "It is not sufficient to study the structure of his dead body in the dissecting-room and the functions of his organs and tissues in the laboratory. To learn what man actually is and does in the world, we have to go out into the world and study him as he lives and works among his fellows. And the same is true of plants." Ecology is concerned not only with natural vegetation, but with vegetation that has been in a greater or less degree interfered with by man. In Part II the reader is introduced to Plant Communities, the Plant Association, the Succession of Vegetation, and other subjects. The next step is to learn how to make an ecological survey of a tract of country; a primary, or extensive, survey must be followed by a more intensive study of the detailed problems of vegetation. The author wisely emphasises the problems which need only simple methods; he writes primarily for the beginner. Part V is devoted to ecological work in schools. Nature Study as taught in some schools has little or no educational value. As Mr. Tansley says, many teachers substitute "facile and largely inaccurate generalisations for observation of nature and sound deduction," instead of training the pupils to observe "the facts of nature as they are, and then to go on to find out as far as possible how they came to be so."

The book is neither cheap nor beautiful, but it is full of sound advice clearly given; it is written by a botanist exceptionally well qualified by experience and by the prominent part which he has taken as a pioneer of plant ecology in this country to speak with authority. Mr. Tansley's book may be confidently recommended to teachers, as also to those for whom botanical inquiry is a hobby and not a profession. A. C. SEWARD.

Philosophical Studies. By G. E. MOORE, Litt.D. (Kegan Paul, Trench, Trübner & Co., Ltd., 15*s*.)

In this volume Dr. Moore collects together ten papers on various philosophical topics, written at various times eight of which have been previously published, mostly in the *Proceedings of the Aristotelian Society*. All the papers, he tells us, are printed without substantial change The best known of these papers is the *Refutation of Idealism*, which appeared in *Mind* in 1903, in which Dr. Moore claims not only to knock the bottom out of Idealism, but also to have detected a "self-contradictory error" which "no philosopher has ever yet succeeded in avoiding." Dr. Moore now says: "This paper now appears to me to be very confused, as well as to embody a good many down-right mistakes." It is a pity that he did not at least add a note to tell the reader where he thinks he has gone wrong. The author himself should be called on to review this paper.

All the papers except two, which are ethical, are concerned with that set of problems usually called the Theory of Knowledge, which occupied the main attention of the classic writers from Descartes to Kant and have never to this day been laid to rest. Dr. Moore is an acute and careful writer, and on all the problems he touches he has some good point to make. He is, however, rather timid and over-cautious. He is always laudably anxious to define precisely the question he wishes to answer—so much so that he sometimes approximates to the method caricatured in one of the Bab Ballads, which spends so much time on explaining what is not its subject that it never reaches a subject at all. He is also—less justifiably in our opinion—very anxious to isolate the question, and in particular to discuss it apart from any wider metaphysical bearings it may possess. This is often annoying, especially when the author brushes these questions aside with an airy, "I do not know whether . . ." One jumps to the classic retort, "Sir, you are *paid* to know!" The distressing frequency of italicised monosyllables and of the parenthetical "I think" are minor symptoms of this weakness, and sometimes give the impression of affectation.

But, if these are defects, they are the defects of qualities: nowhere is precision more valuable and more difficult to attain than in philosophy. If Dr. Moore could only persuade his thought to move on rather more generous lines, suppressing some of the more verbal niceties, he might produce work very much more impressive than anything he has yet written. In the meantime students of philosophy will welcome these collected papers on their own merits. J. L. S.

The Children of the Sun: An Inquiry into the Early History of Civilisation. By W. J. PERRY. (Methuen & Co., 18*s*.)

Mr. Perry's inquiry into the early history of civilisation owes much in its method to the late Dr. Rivers, a debt which the author fully acknowledges in his preface. But the line of investigation which Dr. Rivers followed in attacking the special problems of Melanesia is here developed to such a degree, and applied with boldness and originality to so wide a range of subject, that it may be regarded as striking a new note in anthropological investigation.

Professor Elliot Smith, to whom this volume is appropriately dedicated, and Mr. Perry, as is generally known, are the protagonists on one side of a struggle which has been going on for some time in the world of anthropological study. While it is generaly recognised that the culture of man throughout the world presents certain common features, the opinion current among anthropologists generally is that these common features are mainly, though not always, the result of an independent evolution conditioned by the common mental, moral, and physical constitution of man and his method of reacting to his environment. Professor Elliot Smith, however, influenced by his study of the early Egyptians and their civilisation, has advanced the view that these common elements are due to a diffusion of culture from

one centre, and that centre is Egypt. One of the first cultural features to which the theory was applied was that of mummification, which he pointed out occurred in New Guinea in a form identical in a number of respects with that employed in ancient Egypt, yet not such as was likely to be developed independently. The theory was also advanced as an explanation of the distribution of megalithic monuments (which Professor Elliot Smith derived from the Egyptian *mastaba* or tomb), and certain cultural features associated with them. Mr. Perry then pointed out that this distribution coincided with the occurrence of gold and other precious or useful metals and of pearls, and suggested that those who were responsible for the diffusion of the megalithic culture were pioneers in search of these objects of value to early man.

This part of Mr. Perry's theories has been somewhat severely criticised, and it has been pointed out that the coincidence is not always exact.

In an earlier volume, *The Megalithic Culture of Indonesia*, Mr. Perry has studied the distribution of the culture-complex of which the Megalith is the most prominent feature in one special area. In this work he has extended his inquiry to cover the whole area of North America, Oceania, Indonesia, and India. Taking these areas as one whole, the problem they present to Mr. Perry is this: They contain many communities of a lowly culture which, in some areas, have not advanced so far as agriculture, and yet they also possess traces of an ancient and relatively high civilisation. Mr. Perry's method of solving the problem has been to study the data for evidence of a succession of cultures, and by comparison to trace their modification in the presence or absence of certain features. In other words, he has applied the method of the geologist, who in studying stratification looks to the presence or absence of certain fossils, and of the archæologist, who in excavation establishes his sequence dates by the presence or absence of typical implements, tools, or weapons.

As a result of his comparison on these lines, Mr. Perry has satisfied himself of the existence of an archaic civilisation in the areas he has under consideration, of which the characteristic features, among others, are agriculture by means of irrigation, the use of stone for megalithic monuments and tombs, pottery-making, and the use of polished stone implements. Mr. Perry, however, does not confine himself to material culture, and by further analysis shows that the archaic civilisation also implied a ruling class of two divisions, the dual organisation which is a characteristic feature of so many primitive peoples, a sun cult, a Mother Goddess, human sacrifice, totemism, and exogamy. Not all these features are to be found in every area in which the archaic civilisation is to be found, for fission was a characteristic of this culture, and the separating body did not necessarily carry with it or perpetuate all the features of the culture.

As to the origin and means of diffusion of the archaic culture, Mr. Perry suggests a migration of adventurers whom he calls "The Children of the Sun," adventurers whose wanderings were actuated by their *desire*—an important point in Mr. Perry's theory of archaic psychology—to find and control the sources of supply of raw material for weapons and implements and of precious objects, gold and pearls, valued in the first instance for their magical properties.

The source of this archaic civilisation Mr. Perry holds to have been ancient Egypt, and he pictures the process of the gradual building up of civilisation until its completion by about the time of the VIth Dynasty. Hence it spread gradually until it reached Central America and gave rise to the remarkable civilisation of that area about the beginning of the Christian Era.

In this somewhat summary account of the scope of Mr. Perry's book it has not been possible to do full justice to the care with which he has analysed a vast mass of material, the extent of which may be gauged from the fact that his list of authorities runs to twenty-two pages. Tribute must also be paid to the skill with which he has applied the principles which Dr. Rivers formulated as the result of his Melanesian investigations on the disappearance of useful arts, in his theory of degradation as applied, for instance, to the elucidation of the culture of North America.

Mr. Perry has a skilful knack of meeting and anticipating explicitly or implicitly possible objections to his theories. However they may stand the fire of criticism after mature consideration, and however they may need modification owing to the results of further research, there can be no question that they will have a permanent effect in the development of anthropological method and theory.

Interfacial Forces and Phenomena in Physiology. By Professor Sir William M. Bayliss, F.R.S. (Methuen & Co., 7*s*. 6*d*.)

The fundamental interdependence of the various branches of Natural Science is to-day admitted as a theoretical proposition, but is only too frequently left out of consideration in the arrangement of courses of scientific study. In the concluding sentence of the Herter Lectures, delivered in New York in 1922, and since published under the above title, Sir William Bayliss bewails the lack of adequate preliminary training in general science in the English student of physiology. The whole book may serve as a text to this theme, for it is full of examples, not only of the great importance of physical and chemical principles to the proper understanding of physiological processes, but also of the inadequacy of our present knowledge of the interrelations of these three subjects. Admittedly the chemical doctrine most required by the physiologist is itself in its infancy (the very name of "colloid" was only invented in 1861), but one feels that if more physiologists had, like Sir William Bayliss, the determination to base their work on sound physico-chemical principles, and if more physical chemists realised the enormous field open to them in physiology, it would be to the enormous advantage of both sciences.

In discussing first the physics and chemistry of surface phenomena, and then the manifestations of these in the

living cell, Sir William Bayliss gives an interesting and well-balanced survey both of what is known and of the many gaps in our knowledge. Many of his individual statements will, as he admits, be controverted by other physiologists, notably his views on the relation of hæmoglobin to oxygen. Sir William Bayliss maintains, as is well known, that the observed facts are best explained by the assumption that oxyhæmoglobin is an adsorption compound, in apparent opposition to Hill and others, who consider it to be a "chemical" compound to which the law of mass action applies. But may not the opposition be more verbal than real? The modern tendency is to minimise the distinction between "chemical" and "physical" forces, and it is practically certain that adsorbed substances are attached to the adsorbents at definite "points" of their molecular structure. If we assume one point of attachment per hæmoglobin molecule, and that all the hæmoglobin molecules are accessible, then we shall have an "adsorption compound" in stoichiometric ratio, whose dissociation would be expected to follow the mass action law.

Quite apart, however, from its importance as an exposition in simple terms of the author's views on this and other problems, the book will be of value to physical chemists and physiologists in indicating in what directions co-operation is most needed, and in encouraging that open-mindedness and breadth of view which is characteristic of Sir William Bayliss's scientific attitude.

D. C. HENRY.

Sidney Ball. Memories and Impressions of "An Ideal Don." Arranged by OONA HOWARD BALL. (Oxford: Basil Blackwell, 10*s.* 6*d.*)

Lack of space forbids us to write as long a review of this book as we should like. Sidney Ball did more than any other "don" of his generation to convert Oxford University from the narrow views of a single class and to place it in touch with the progressive ideas that were growing up outside it. Undergraduates who went to St. John's College will remember him with affection and veneration, and many persons outside his university, well known and unknown, will carry the inspiration of his personality through their lives. The biography has been admirably arranged by Mrs. Ball and contains impressions, among others, by Sidney Webb, Sir William Ashley, Professor Gilbert Murray, and Dr. Farnell.

E. L.

ERRATUM

The price of *An Introduction to the History of England*, by Mr. (not Dr.) C. R. L. Fletcher, reviewed in our last number, should have been given as 9*s.*

Books Received

SCIENCE

The Mechanism and Physiology of Sex-determination. By RICHARD GOLDSCHMIDT. Translation by W. J. DAKIN, D.Sc. (Methuen, 21*s.*)

The Geology of the Metalliferous Deposits. By R. H. RASTALL. (Cambridge University Press, 21*s.*)

Principles and Practice of Wireless Transmission. By G. PARR. (Ernest Benn, Ltd.)

Newer Aspects of the Nutrition Problem. By F. GOWLAND HOPKINS. (Oxford University Press, 1*s.* 6*d.*)

Journal of Scientific Instruments. Vol. I, No. 1. (The Institute of Physics, 2*s.* 6*d.*)

The Genesis of Petroleum. By PERCY EDWIN SPIELMANN, Ph.D., B.Sc., etc. (Ernest Benn, Ltd., 5*s.*)

The Properties of Matter. B. G. MCEWEN, M.C., B.Sc. (Longmans, Green & Co., 10*s.* 6*d.*)

Founders of Oceanography and Their Work. By SIR WM. HERDMAN, C.B.E., D.Sc., F.R.S. (Edward Arnold & Co., 21*s.*)

Relativity. A Systematic Treatment of Einstein's Theory. By J. RICE, M.A. (Longmans, Green & Co., 18*s.*)

Practical Chemistry for High Schools. By H. B. DUNNICLIFF, M.A., B.Sc. (Macmillan & Co., 5*s.*)

Statistical Method. By TRUMAN L. KELLEY, Ph.D. (Macmillan & Co., 18*s.*)

Practical Physical Chemistry. By ALEXANDER FINDLAY, M.A., Ph.D., D.Sc. 4th Edition. (Longmans, Green & Co., 7*s.* 6*d.*)

The Expert Witness. By C. A. MITCHELL, M.A., F.I.C. (Cambridge: Heffer & Sons, Ltd., 7*s.* 6*d.*)

British Hymenoptera. By A. S. BUCKHURST, L. N. STANILAND, and E. B. WATSON. (Edward Arnold & Co., 9*s.*)

Vitamins. A Critical Survey of the Theory of Accessory Food Factors. By RAGNAR BERG. Translated by EDEN and CEDAR PAUL. (George Allen & Unwin, Ltd., 18*s.*)

Mnemic Psychology. By RICHARD SEMON. Translated by BELLA DUFFY. (George Allen & Unwin, Ltd., 14*s.*)

Chemische Grundbegriffe. By A. BENRATH. Harrap's Bilingual Series. (G. G. Harrap & Co., Ltd., 2*s.*)

Radio-activity. By K. FAJANS. Translated by T. S. WHEELER and W. G. KING. (Methuen & Co., 8*s.* 6*d.*)

The Structure of the Atom. A Supplementary Chapter to *Modern Electrical Theory.* By N. R. CAMPBELL, Sc.D. (Cambridge University Press, 10*s.*)

Flying. By MAJOR W. T. BLAKE. (George Allen & Unwin, 6*s.*)

From Determinant to Tensor. By W. F. SHEPPARD, Sc.D., LL.M., Formerly Fellow of Trinity College, Cambridge. (Clarendon Press, 8*s.* 6*d.*)

Essays of a Biologist. By JULIAN HUXLEY. (Chatto & Windus, 7*s.* 6*d.*)

Popular Fallacies Explained and Corrected. 3rd Edition. By A. G. E. ACKERMANN. (Old Westminster Press, 12*s.* 6*d.*)

Recent Developments in Atomic Theory. By LEO GRAETZ. (Methuen & Co., 9*s.*)

Principles and Practice of Wireless Transmission. By G. PARR. (Messrs. Benn Brothers, 5*s.*)

Wireless Telephony. A simplified explanation. By R. D. BANGAY. (The Wireless Press, Ltd.)

Time and Weather by Wireless. By W. G. W. MITCHELL. (The Wireless Press, Ltd.)

Diary 1924. (The Wireless Press, Ltd.)

The Principle of Relativity. By ALBERT EINSTEIN, H. A. LORENTZ, H. MINKOWSKI, A. SOMMERFELD, and H. WEYL. Translated by G. B. JEFFERY, D.Sc., and W. PERRETT, Ph.D. (Methuen & Co., 12*s.* 6*d.*)

Eclipses of the Sun. By S. A. MITCHELL. (Humphrey Milford, 17*s.*)

THE ARTS AND HUMANITIES, ETC.

From Immigrant to Inventor. By MICHAEL PUPIN. (Charles Scribner's Sons, 18*s.*)

The Philosophy of Proof. By the late J. R. GULSON. (George Routledge.)

Burns's Income-tax Guide. Fifth Edition. (W. Green & Son, Ltd., 2*s.* 6*d.*)

Londinium. Architecture and the Crafts. By W. R. LETHABY. With 175 figures. (Duckworth & Co., 12*s.* 6*d.*)

A History of Art. By DR. G. CAROTTI. Vol. III, "Italian Art in the Middle Ages; Art in Upper and Southern Italy." Translated by JANET ROSS. With 357 illustrations. (Duckworth & Co., 8*s.*)

A Nuer-English Vocabulary. Compiled by the late C. H. STIGAND. (Cambridge University Press, 2*s.* 6*d.*)

The Legacy of Rome. Essays edited by CYRIL BAILEY. With an Introduction by the RIGHT HON. H. H. ASQUITH. (Oxford: Clarendon Press, 8*s.* 6*d.*)

The Pronunciation of Russian. By PROFESSORS M. V. TROFIMOV and DANIEL JONES. (Cambridge University Press, 6*s.*)

Psychology and Primitive Culture. By F. C. BARTLETT. M.A. (Cambridge University Press, 8*s.* 6*d.*)

Aberrations of Life. By JAMES CLARK MCKERROW, M.B. (Longmans, Green & Co., 6*s.*)

Voices from Another World. The Waking Dreams and Metaphysical Phantasies of a Non-Spiritualist. Edited by F. GURTIS. Authorised translation by L. A. CLARKE. (George Allen & Unwin, Ltd., 8*s.* 6*d.*)

My Commonplace Book. By J. T. HASKETT. 4th Edition, revised and enlarged. (Macmillan & Co., Ltd., 12*s.* 6*d.*)

Friedrich Hölderlin and the German Neo-Hellenic Movement. Part I. By MARSHALL MONTGOMERY, M.A., B.Litt. (Humphrey Milford, 10*s.* 6*d.*)

Correspondence

ANCIENT MAN IN BRITAIN

To the Editor of DISCOVERY

SIR,

In his rambling remarks regarding my book *Ancient Man in Britain* Mr. Fallaize adopts a tone which may be regarded by some as proof of critical acumen. He would have your readers believe that although I have collected a great mass of important evidence, I am not capable of making effective use of it, being a somewhat irresponsible "extremist." My chief fault appears to be that I refuse to apply to anthropology the hazardous theory of spontaneous generation. In my opinion one must either accept this theory or reject it. There is no "half-way house"—no fence on which one can sit. One must be perfectly frank and honest and have the courage of one's opinions. Mr. Fallaize refers respectfully to the late Dr. W. H. R. Rivers and to Professor Elliot Smith, both of whom have rejected the theory of the spontaneous generation of the same complexes in different parts of the world; but, in dealing with me, he attempts to ridicule a view which, as it happens, met with the approval of Dr. Rivers. Mr. Fallaize says I identify "a goddess of the Hebrides with a goddess of Egypt through a shell and milk cult, but," as he puts it, "to point out an analogy is not necessarily to prove a connection." What, then, is proved? This tree goddess could not have possibly had spontaneous generation in the treeless Outer Hebrides. She has quite evidently been imported, and when we find that she is closely associated with a group of complex beliefs and customs similar to those connected with the cult of the fig-tree in Greece, one is not necessarily an extremist if one favours the view that she was imported from the Continent. Those who pretend to know much about the greatest of all mysteries, the working of the human mind, may think it "natural" that the ancient Hebrideans should have associated sea-shells with milk and milk with a tree, and shells and milk with certain precious and semi-precious stones. But there is really nothing "natural" about these arbitrary associations. The so-called "analogy" remains to be accounted for. It has a history. When we find that owing to a set of fortuitous circumstances in ancient Egypt, the goddess Hathor was associated with sea-shells, trees, the sky, a domesticated animal, and certain precious and semi-precious stones, one expects to find, if there is anything in the theory of spontaneous generation favoured by Mr. Fallaize, that a similar set of fortuitous circumstances brought into existence in the Outer Hebrides a complex deity similar to the Egyptian Hathor. If some of your readers are prepared to admit the possibility that the ancient Hebrideans had precisely the same experiences as the ancient Egyptians, it would be as well to remind them that the same tree-shell-and-milk beliefs are found in India and elsewhere in Asia, and that it is therefore necessary to accept the view, apparently favoured by Mr. Fallaize, in dealing with India and China as well as the Outer Hebrides. Having done so, I can smile if I am still called an "extremist." Mr. Fallaize even goes the length of alleging that I do not "appear to have digested" my "material thoroughly." Perhaps, after all, it is better to have something left to digest than to have merely an empty stomach.

Yours, etc.,

DONALD A. MACKENZIE.

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